ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 62. No. 12. 220 Broadway, New York, September 16, 1909.

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The 180-Ft. Stone Arch Bridge at Wiesen, Switzerland.

The view on this page shows an arch bridge of unusual proportions which has been built on a metre-gage branch railway between Davos and Filisur, in Switzerland. The bridge crosses the valley of the Landwasser, a mountain stream, near the town of Wiesen. Its central part is a lofty stone arch spanning 180 ft. (55 m.) in the clear, whose deck is 320 ft. above the valley bottom; flanked by six 66-ft. spans, the arch makes a striking picture in the mountain landscape.

Good stone being not readily available, this bridge was built of cut-stone facing with a backing of concrete blocks molded on the ground. The structure is therefore essentially a concrete-block arch, the first large arch of this nature.

The centering on which the large arch was built is particularly interesting, first because of its size and second because of its peculiar construction, as it simulates an arch in form but really consists of two towers corbeled out over the gorge and a truss frame resting on them. It is interesting to contrast it with the centering used for building the Petrusse arch at Luxemburg (Eng. News, Feb. 27, 1902, p. 179).

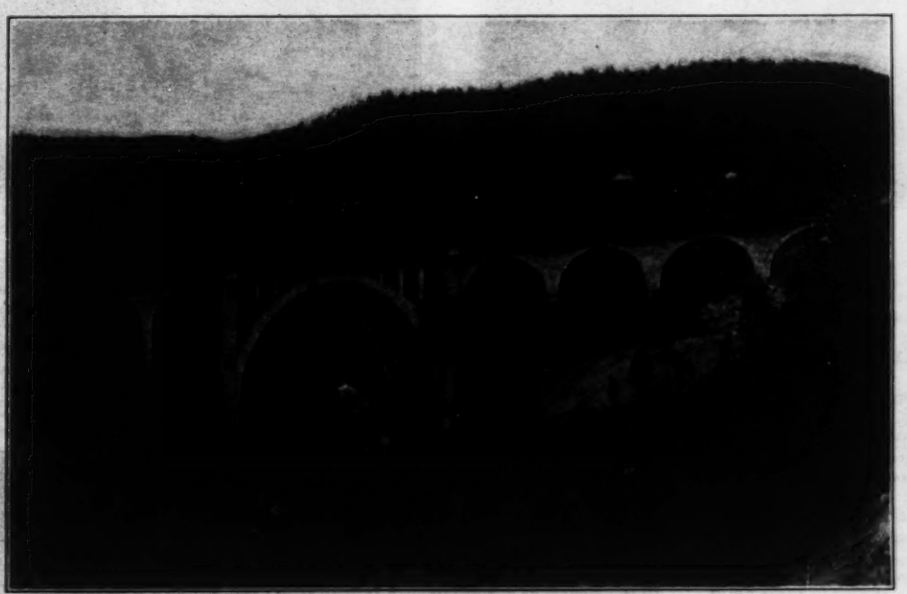

FIG. 1. STONE ARCH RAILWAY BRIDGE OVER LANDWASSER RIVER AT WIESEN, CANTON GRAUBUENDEN, SWITZERLAND.

(The large arch has a clear span of 180.4 ft. and a rise of 100.4 ft. Its curve is three-centered. The roadway is about 300 ft. above the river.)

From a full description of this structure and other features of the railway, in the "Schweizerische Bauzeitung" of June 5 to 26, 1909, we take the following information.

Davos-Filisur Railway.

The railway on which this notable bridge is located has a total length of only 11¾ miles, but it lies in very difficult mountain country and was correspondingly complicated by steep grades, sharp curves and many tunnels and bridges. It connects the resort Davos-Platz, on the Rhaetian Railway system, with Filisur, a station on the Albula Ry. (Eng. News, Dec. 19, 1901, p. 479). The drop to Filisur is 1,510 ft., so that the average gradient of the line is nearly 2¼%. Over half of the total length, however, has a 3½% gradient. Some characteristic figures, arranged in tabular form for clearness, are as follows:

Length of railway	11¾ mi.
Davos-Platz above Filisur	1,510 ft.
Maximum grade	3.5%
Per cent. of line on grade	80.5%
On grades over 2%	64.9%
On maximum grade	50.3%
Minimum curvature, R = 395 ft.	14° 30′
Per cent. of line on curve	40.6%
On curve over 10°	17.5%
On sharpest curve	9.2%
Per cent. of line in tunnel	22.3%
On bridges	6.4%

The railway was begun in 1906 and was completed and opened for traffic in the summer of 1909. Mr. P. Saluz was Chief Engineer; the article from which we draw was written by him.

For the most part the line runs through narrow valleys or gorges, where avalanches and rock falls are common. The worst of the avalanche paths were avoided by tunneling under them. At two tunnel portals where rock falls were feared a masonry protection shed was built out about 50 ft. beyond the portal. One of these is shown by Fig. 5 herewith, at a point where the railway runs from a stone arch viaduct into a tunnel.

The Wiesen Arch Bridge.

The great river crossing at Wiesen is shown well by the general view on this page. This, as well as the other photographic views illustrating the present article are from photographs in the possession of Mr. W. Dietschi, Engineer, Wiesen, Switzerland. The lower part of the valley is very narrow and steep, as the profile in Fig. 6 exhibits. The topography favors a long span, but the engineer states that the stone arch design cost but little more than a steel design employing a 260-ft. middle span (presumably with masonry piers).

The total length of the structure is 689 ft. There are four 20-m. (66-ft.) spans on the Wiesen side of the central arch and two similar spans on the Filisur side.

The roadway on the bridge is on maximum grade, 3.5%. In alinement it is straight over the central arch and the upper approach, but the lower approach is on 14½° curve, beginning at a point practically over the main pier on the south or Filisur side. The two 66-ft. arches of this approach lie along chords of the curve.

DESIGN.—The central arch, 55 m. (180 ft.) clear span, Fig. 6, was designed with free arch ring, the roadway being carried by small secondary arches spanning 4 m. (13 ft.) between piers or pillars resting on the main arch. The arch ring was laid out to fit the dead-load pressure line as closely as possible. It is three-centered, but on account of the high ratio of rise to span the smallest radius is used for the crown section, whereas ordinary three-centered arches have flattest curvature at the crown. The intrados has crown radius of 22 m. (72.1 ft.) and haunch radius of 36.5 m. (119.8 ft.). The intrados has radii of 27 m. and 37 m. (88.5 and 121.3 ft.). The ring thickness at the crown is 1.8 m. (5.9 ft.), and at the actual skewback, which is inclined 16° to the horizontal, it is 3.016 m. (9.9 ft.).

The compressive stresses in the ring were limited to 335 lbs. per sq. in., or 24 tons per sq. ft., which is the actual maximum stress due to dead and live-loads, braking of trains, wind and temperature. Stone masonry was to be used, employing local stone. But during construction the fact developed that the only local stone which could be quarried without great expense was very poorly suited to cutting and dressing, as needed for the arch voussoirs. As the work already was behind schedule time, the chief engineer authorized the contractors to use molded concrete blocks for the core of the arch-ring. The arch therefore is in substance a concrete-block arch with cut-stone facing.

The main piers are of concrete, with cut-stone facing.

The side spans, each 20 m. (65.6 ft.) in the clear, have a true semicircle as intrados curve. The springing line was taken as lying 4 m. above the point of tangency of the curve, or at an angle of about 23½° to the horizontal. These arches have full spandrels.

FIG. 2. CENTERING COMPLETED AND MAIN PIERS HALF BUILT.

FIG. 3. LAYING UP THE SECOND BELT OF THE ARCH-RING.

CONSTRUCTION.—The large arch was built on arch-shaped timber centering, spanning the gorge of the creek. A steel truss centering resting on abutments well up on the side of the main piers had been proposed, but the contractor preferred the timber construction.

The centering is shown quite fully by the sketch Fig. 7 and Fig. 2, a view when completed. The lower two-thirds on either bank forms a solidly bolted frame, leaning out over the gorge. The upper part, which spans across the opening, rests on the lower by means of sandboxes and wedges. The bracing is all of timber, except that a wind anchor system of steel rods was provided at the top of the lower section, as shown by plan in Fig. 7. Both the upper and lower parts, moreover, are anchored back to the main piers by 1¼-in. rods fitted with turnbuckles.

In order to save timber in the centering, the arch was designed to be laid up in three concentric rings or shells, of which the first should be strong enough to carry the second without transmitting the added load to the centering. The centering was proportioned to carry only about half the total weight of the arch ring. The stresses in the members were calculated on the basis of a friction angle of 26° for the friction between masonry and lagging.

The frame is composed of four sets or trusses, equally spaced (52½ ins. c. to c.); though these receive unequal parts of the total load they were built alike, each being proportioned for one-third the load, which is about the share coming on each of the two middle sets.

The framing is very heavy, as shown by the section provided in the lower panel of the inner rib, 90 × 28 cm. (about 35½ × 11 ins.). The stress in this rib member is about 300 lbs. per sq. in. (total stress 63 tons). At all joints where endwood rested on sidewood, bedding corbels of channel iron were interposed, to reduce the cross-grain compression. Fig. 8 gives an excellent detail view of part of the frame.

The devices for lowering the centers comprised 24 sandboxes (3 on each half of each truss) and 16 pairs of wedges, as shown in the drawing.

This center frame required about 2,200 M. B. M. timber and 22 tons steel. The labor cost of framing, erecting and taking down is given as 22,500 francs ($4,500).

The centering being completed in August, 1908, the arch masonry was begun at once. The ring was laid in full thickness up to a joint-slope of 35°, where the three-shell construction begins. The subsequent arrangement of the sectional construction (generally employed for large arches) is given in the following summary:

Aug. 6-23, 1908.—Laying up full thickness of ring from skewbacks to joint 35°, leaving at 26° an open joint in the extrados to the depth of one-third the ring thickness.

FIG. 5. PROTECTION GALLERY AGAINST ROCK FALLS, AT JUNCTION OF TUNNEL AND ARCH-VIADUCT.

FIG. 4. ARCH AND SUPERSTRUCTURE COMPLETED.

centering, Fig. 3 the arch during work on the second ring, and Fig. 4 the completed arch.

The face blocks were cut chiefly from drift stones collected in the valley. Two quarries were opened in the limestone country-rock, but it soon appeared that while this stone was well suited to the rubble foundation work it did not cut readily for the arch work. It was at this stage that the use of concrete blocks for the core of the arch-ring was authorized, excellent sand and gravel being available nearby.

Hand-mixed concrete was used, tamped into wooden molds, the blocks stored in moist air (a nearby tunnel of the railway) until two months old. They were all 10 × 20 ins. on beds, but varied in thickness from 6 to 10 ins. to suit the different thicknesses of the face stones.

The strength of these blocks was ample for the stresses employed. Compression tests of cubes (size not stated) molded simultaneously with the blocks showed strengths of about 5,000 lbs. per sq. in. at 30 to 60 days! Because the blocks give thinner joints and (by their regularity) a better bond than stone, the engineer considers that an excellent piece of masonry was obtained (see Fig. 9). However, for better transverse bonding, steel tie-rods were bedded in the arch-ring, tying the face-walls together. Sixteen 3 × 7-16-in. rods were thus placed in the arch-ring of the main span, and five in each of the 66-ft. arches.

The centers of the large arch were dropped 3 ins. on Oct. 14, six weeks after the keying of the first ring. No settlement was observed, nor had any been noticeable during the construction of the second and third rings of masonry. The only settlement, 4 ins., occurred during the laying of the first ring. The scheme of having the inner ring carry the wright of the others appears therefore to have succeeded.

In striking centers, a man was stationed at each sandbox or wedge, and the work was done in successive stages of ¼-in., with great care to get uniform lowering.

The columns, secondary arches and roadway fill of the large arch were put in during October and November, favored by good weather. The final completion of the roadway had to be left until the spring of 1909.

The 66-ft. arches of the approach viaducts were built by a procedure somewhat similar to that for the large arch, but simpler. The form of centering employed was of course quite different (see Fig. 10). The arch nearest the Wiesen end was built first, while the other five were laid up simultaneously. The rings were laid up in two thicknesses, the inner shell being keyed at three points simultaneously.

The backs of the side arches were waterproofed with fabric and asphalt on a 2-in. surface coat of cement. The crown part of the large arch was waterproofed by covering with sheet-lead, flashed

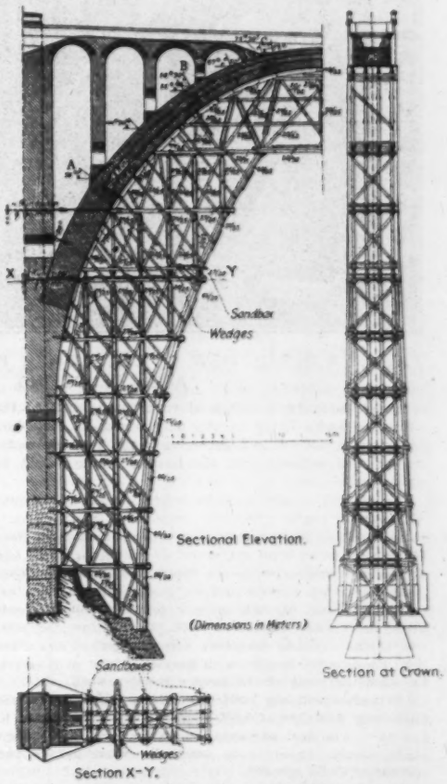

Fig. 7. Sketch of Centering of Wiesen Arch.

up against the spandrel walls. A sand cover protects the waterproofing from the stone fill.

The entire bridge is stated to have cost about $80,000. This includes no cost of material in the centers. Mr. H. Studer was Resident Engineer. The contractors were Froté, Westermann & Co., of Zürich. Mr. Marasi, their engineer, designed the centering, and Mr. R. Coray built and erected it.

In connection with the interesting views of the two centers used for the large and the small arches of this bridge, we show in Fig. 11 another center-frame, used for building a 79-ft. arch on another part of the same railway. This center is also of the arch type, and crosses a rather deep gorge.

Aug. 25-Sept. 4.—Laying up inner ring from temporary abutments at points A, B and C, Fig. 7, leaving open joints at 35°, 44½°, 56½°, 67½°, 78° and crown. The thrust was transmitted across these joints by vertical ribs of neat cement mortar, 3 ins. wide and 10 ins. apart.

Sept. 5-6.—Closing joints at 44½°, 57½° and crown, by tamping full of cement mortar. The six intermediate joints were left open until the completion of the second ring.

Sept. 10-23.—Laying up second ring from the same points A, B, and C, keeping open joints over the six remaining joints of the masonry below.

Sept. 24.—Closing the open joints (at 35°, 56½° and 78°) throughout the depth of second and first rings.

Sept. 25-Oct. 10.—Laying up third ring, from the finished work at 35° continuously to the crown, keying at the crown.

Oct. 10.—Closing the open joint of outer third at 26°.

Figs. 2, 3 and 4 are progress views of the masonry work, the first showing the piers and the

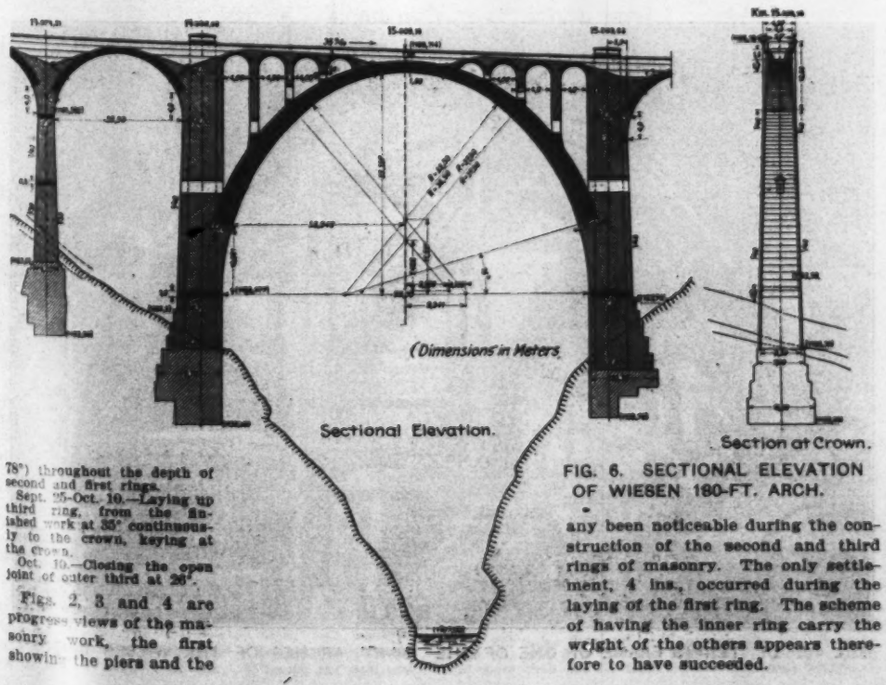

FIG. 6. SECTIONAL ELEVATION OF WIESEN 180-FT. ARCH.

A DUMP CAR of peculiar design, which is intended to prevent the sticking of the load, has been tried on the Duluth, Missabe & Northern Ry. for handling ore. The body or box is supported by trusses on either side, and consists of two parts, hinged together at the top at the mid-length of the car. Under each end of the body is an air cylinder for elevating the end, so that the two portions separate at the middle and the contents are discharged between the rails. The maximum width of opening is 5 ft., with the two parts inclined at an angle of 50°. The car is 22 ft. long, weighs 17 tons, and has a carrying capacity of 50 tons. It is known as the Rakowsky car, and is built by the Automatic Unloading Car Co., of Duluth, Minn.

Some Railway Surveys and Their Cost.*

By W. S. McFETRIDGE,† M. Am. Soc. C. E.

This paper is intended to give a general description of some extensive railway surveys, a brief outline of methods and results, and the cost per mile. The writer does not remember having seen a similar statement covering so many miles (1,400 miles of preliminary lines and 600 miles of location).

Early in 1902 the Little Kanawha Syndicate began surveys for extensions eastward from Palestine, W. Va., to Belington, and westward from Parkersburg, W. Va., to Zanesville, Ohio. About 1½ years later it took up the location of a line running northward from Belington to the Pennsylvania-West Virginia State line. The termini, as usual, were fixed. Physical conditions also fixed the Little Kanawha River as the only outlet to the Ohio. These points decided in a general way the proposed route. It was also believed that the heavier traffic would be westbound.

FIG. 8. A DETAIL VIEW OF THE LOWER PART OF THE 180-FT. ARCH CENTERING.

The desired results may be briefly stated as follows: (1) Easiest grades possible, especially against westbound traffic; (2) lightest curvature; (3) shortest line; (4) occupy to as great an extent as possible critical and strategical points, so as to block the route to other lines; (5) reach certain definite places previously determined on; and (6) taking into consideration the naturally heavy and expensive work on any line, the total cost should compare favorably with the cost of any other line, many miles longer, with heavier grades and curves, but avoiding some of the most expensive work.

All roads previously built through the adjoining regions have long stretches of 1.5% grades, and curves up to 12 and 14°. The first surveys, therefore, were of a preliminary nature, in order to determine what grades and curves could be secured.

After a number of surveys, locations, and explorations had been made, it was found that the following grades and curves were possible; in Ohio, 0.5% grades, 4° maximum curve; Little Kanawha Division, 0.3% grades, 8° curves; Burnsville & Eastern Division, 1% grades against eastbound and 0.5% grades against westbound traffic, 8° curves. All grades compensated for curvature at the rate of 0.04-ft. per degree. These results were kept in view in continuing the surveys, and were obtained in each case.

It was desired to avoid all momentum grades, and only in one case was it found necessary to use them. In this case such a grade was introduced in order to avoid a long detour combined with some exceptionally heavy work. At some future time this grade can be taken out if desired. In the meantime, for any ordinary reason of operation, a train need never stop there, and thus get stalled. There is no station stop, and a water-station or siding is not feasible, on account of local conditions, so that trains can always "run for the hill."

The grades desired were very easy for parts of the country, and required some rather long continuous grades. The longest are on the Burnsville & Eastern Division, where there are 1% grades, 7 and 7½ miles long, respectively, and a grade of 0.6%, 14 miles long, all against eastbound traffic. To obtain these grades it was necessary to make a thorough study of the country and a detailed examination of several routes.

The topographical sheets of the U. S. Geological Survey were found of great value in making a broad, general study of the country. They were usually found quite accurate in regard to main summits, large rivers, and towns, but intermediate details were always more or less inaccurate.

A large number of maps of small scale (1 in. to 1 mile or even smaller) were compiled and traced from various state, county and road maps, on which the several survey lines could be indicated. Such maps are of particular value, and should be the first ones prepared—if possible before any surveys are made.

The general direction of the survey, except along the Little Kanawha Division, was almost directly across the general drainage of the country.

In Ohio, a direct line between termini was first examined, but was found to be impracticable. A systematic examination toward the southwest was then made, and finally a satisfactory line was developed, over which a final location was made. All the streams here lie in deep, narrow valleys, and are exceptionally crooked. The only feasible way to traverse much of the country was to get up out of the valleys and stay out. This necessitated crossing about 100 ft. above several streams, and running short tunnels between the waterheds. It also gave the shortest line, the easiest grades, and the lightest curvature. Any attempt to avoid the high crossings or tunnels involved long detours, excessive curvature, and heavier grades.

The Little Kanawha Division, in general, followed the Little Kanawha River. The hills rise abruptly from the river banks, the slopes often being as steep as 1½ to 1. The river is very crooked, and to follow it gave a long line with much curvature. Much distance could be saved by cutting through the country at various points, but the work was very heavy. The bottom lands are narrow and subject to overflow several times a year, the river sometimes rising 20 ft. in a day. A river line would have to be built along the steep side-hills for most of the way (this being expensive), or else be subject to inundation during high-water seasons.

The hills are cut through in all directions by numerous tributary streams. The grade of the streams is from 50 to 80 ft. per mile, their length varying from 1 or 2 to 20 or 30 miles, and all of them terminate against abrupt hills. Many previous surveys had been made, and practically all of them followed the river, abandoning any serious attempt to shorten the line materially by cutting across country. Our first survey also followed the river, and a complete location was made. This line was run principally for information, and was abandoned.

The main problem on this division was to locate such a line that its total cost would not greatly exceed the cost of a river line equally well built (though no definite amount was ever fixed for this), that its grades and curves would be as light as by river, and that it would be as short as possible. This problem required minute study of the land, a thorough knowledge of its character, the running of many lines, and the comparison of many estimates. On a first examination of this country one was inclined to say offhand that it was impracticable to leave the river for any material distance because the cost would be prohibitive. But when a thorough study began to show the length of line that could be saved by a mile or two of enormous work, the question had a different aspect. The only way to get sufficiently accurate data, on which to base final conclusions, was to make the actual surveys of the different routes.

Fig. 9. The Back of the Large Arch During Construction, Showing Concrete-Block Core.

One item which was always more or less an unknown quantity, but which was the deciding point between two lines, in more than one case, was the treacherous character of some of the side-hills. It often happened that quite a large area, and sometimes from 15 to 20 ft. deep, would move bodily down hill for several feet when disturbed by any construction work. To avoid these places as much as possible, and to estimate their probable cost when comparing lines, were difficult problems.

On location, a plan sometimes used was as follows: Where the grade was near the foot of a hill, the location was thrown away from the hill, in order to avoid cutting

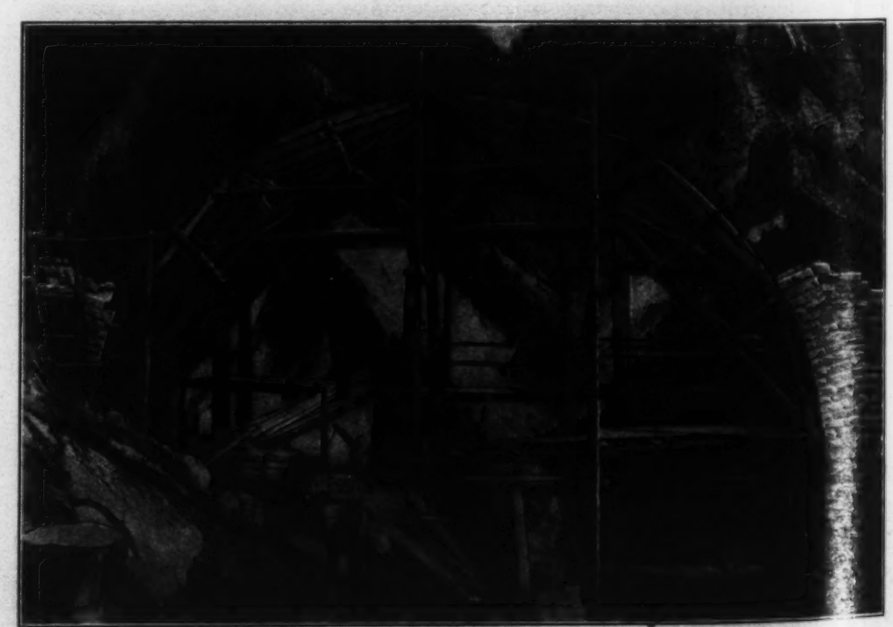

FIG. 10. CENTERING FRAME OF ONE OF THE 66-FT. ARCHES OF THE WIESEN BRIDGE.

*Abstract of a paper in the "Proceedings" of the American Society of Civil Engineers for April, 1909.

†Greenville, Mercer Co., Pa.

the slopes; this gave a fill where it was not apparently necessary, but it was cheaper in the end. When the grade was high up on the hillside, the opposite was done, for the purpose of getting the roadbed on solid ground. In many cases, however, such places could not be avoided in any way, and it was often found that ground, to all appearances perfectly firm, would slide after construction started. In comparing the various lines, this tendency to slide had to be taken into account, but the estimate of cost was of necessity more or less an approximation. These slides, throughout this country, are frequently a very large item of cost in building, and are usually underestimated.

The line, as finally located, is a combination of river and cross-country line. It is 31 miles shorter than the river, in a total distance of 100 miles. There are eight tunnels, usually short, the longest being 4,000 ft. There are seven river crossings, with main spans from 100 to 300 ft.

The Burnsville & Eastern Division is in the central mountain part of the state. The highest altitude reached is 1,725 ft. above sea level. At the junction with the Little Kanawha line, the altitude is 750 ft. It was about as difficult to find the 0.5% grade west as to find the 1.0% grade east. The first line examined developed the fact that, owing to the rapid rise of the land at the eastern end, it would be necessary to use the maximum grade at once for getting out of the Little Kanawha watershed, and then follow around the headwaters of the streams to the north, in order to get supporting ground. The line finally located was outside of the Little Kanawha watershed.

FIG. 11. LAYING UP A 79-FT. STONE ARCH.

Organization and Work.

Field parties were made up as follows:

	Monthly salary.		Monthly salary.
Asst. engineer in charge	$125 to $150	Rear flagman	$40
Transitman	85 " 100	Stakeman	35
Leveiman	75	Axeman (from 2 to 5).	30
Rodman	65	Topographer	65
Head chainman	50	Tapeman (2)	45
Rear chainman	45	Draftsman (part time).	60

Camp outfits were not used. The parties boarded at houses along the line. This was often a disadvantage, on account of difficulty in getting quarters, especially for a full corps; but, on the other hand, the party could frequently make its headquarters at some town and drive to and from the work, so that probably this method served just as well as furnishing camp outfits. Each party was given from 40 to 60 miles of line to cover, depending on local conditions. The assistant engineer was not expected to spend all his time with the party, but to be with it enough to see that work was going on satisfactorily, and that lines were being run over the proper routes. The remainder of his time was spent in a thorough study of the country, picking out routes to be examined, and looking after his office work. On location and in particularly difficult country he was to be with the party almost constantly.

After the first route to be examined had been chosen, a preliminary line was run through; then the alternative routes were run, all surveys being tied together; and finally the lines required for a thorough development of all possible routes were run. Although the first preliminary line might give the grades and curves desired, and possibly be the line over which the final location was made, it was not finally determined on until the subject was fully investigated.

Sometimes all the preliminary data required over a certain route may be obtained quickly by stadia methods, but some sort of a definite line is required from which reliable conclusions can be drawn. Especially is this true in heavily timbered, hilly country, where the range of vision is very limited, and traveling on foot is excessively wearisome, and unless such a method is used some feasible route is very likely to be overlooked. Many times on these surveys the assistant engineer was sent back over parts of the line to hunt out something better, and often with success.

In locating long grades, it was preferable to start at a summit and run down hill. With a little experience, the assistant engineer could make a sufficiently close estimate of the amount to allow for compensation for curvature, and could run his line accordingly. In the mountainous part of the country here described this compensation amounts to about 6 ft. per mile.

In case of the choice of two apparently equal routes, a location was made over each, and estimates were prepared for comparison before choosing a line. In following the larger watercourses, it was usual to locate a line on either side for purposes of comparison, and in order to determine the advisability of crossing from one side to the other either to get a better line or to block the country against rivals.

It may appear that there was much unnecessary location and running of preliminary lines, but in rough country like this, and on work of this magnitude* it is time and money well spent. In no other way can the exact information be obtained, and it leaves no question as to the available routes and the grades obtainable.

The locating engineer, or others on the ground, may feel certain that a line is not feasible, but it is hard to furnish proof except by map and profile. Again, an apparently hopeless line may show up much better than expected, or the reverse. The writer must not be misunderstood to mean that anyone can get the best location if he only runs lines enough. Lines can be run indefinitely without securing the desired results, unless the proper judgment and knowledge are combined with them, the location being usually the most difficult problem of railway work. What is meant is that it is necessary to run a sufficient number of lines, preliminary and location, to arrive at correct conclusions and to get the requisite exact data to prove the conclusions.

Topography, showing contours, houses, roads, watercourses, etc., etc., was taken on practically all lines. This was taken on sheets 12 × 18 ins. The transit line was plotted each day on the requisite number of sheets; a light pencil line, at right angles to the center line, was drawn through each station, for ease in plotting the topography; elevations were marked at each station; the stations where contours crossed the center line were determined from the profile and marked; connections to other sheets were shown, and then the sheets were ready for field use. The lines were plotted to a scale of 200 ft. to 1 in. The topography was plotted in the field. A hollow drawing-board, 18 × 24 ins. was used. The sheet in use was tacked to the board, and the additional sheets were carried inside. A strap around the shoulders of the topographer served to carry the board, and formed a support while plotting (Wellington's method).

This method was preferred to any other. It is quicker; saves much copying and plotting; the work can be plotted better in the field, where everything can be seen at the time of plotting; and at night the assistant engineer has a finished map to look over and study. The topography was taken accurately by using a metallic cloth tape for distances and a hand-level for elevations. Only in this way can one get a projected location to correspond closely with the actual one. The topography was ordinarily taken for 300 ft. on each side of the center lines. At particularly difficult summits or similar places a strip from 1,000 to 2,000 ft. wide was often shown, the necessary topography being obtained by auxiliary lines. The sheets were inked in each night.

To obtain a large general map showing all lines, the lines were carefully plotted on tracing cloth, the small sheets were fitted so as to make the center line on each sheet fit the center line on the tracing, and then the topography was traced. By this method any error in plotting or joining the small sheets was eliminated from the large map. This tracing, from which blue prints were made as required, was retained in the office, the sheets being used for rough work and field use.

The location was projected in pencil on sheets in the usual manner, care being taken to determine all angles between tangents by the calculated courses from each sheet, not by using a protractor, or by measuring intersection angles, although either might be used as a check. After the line was located on the ground, the location was accurately tied to the preliminary line and replotted on sheets. The pencil projection was then erased, if so desired.

In staking out the location, the aim was to get a profile to correspond with the projection, and not to get the lines in exactly the same relative positions shown by the projections. The lines always varied more or less in their relative positions. Also, it was often found desirable to change the location at places, giving a corresponding change in the profile. For instance, it might be decided in the field that, owing to surface conditions, certain hills could be hit harder or perhaps avoided. The most frequent change was to put the line harder into steep side-hills. When projecting lines along such places, there is nearly always a tendency to fit the line too closely to the surface and not to allow enough cutting to put the roadbed on firm ground.

Owing to these facts, it is usually better to have the first location projected and run in by the field engineer, who is most familiar with actual conditions; after that the revisions and necessary changes can be taken up by the higher officers. Projections made by anyone not thoroughly familiar with the ground should be used with caution. The best location cannot be obtained without the topography and a projected line. It cannot be obtained on the sheets alone, without a thorough and complete knowledge of the character of the country. The two must be studied together, the field engineer at all times corresponding freely and fully with the chief engineer and getting his ideas and instructions.

After the first location had been made, it was studied further in the chief engineer's office. If any changes were desired they were taken up with the assistant engineer, usually by the assistant chief engineer and assistant engineer going over the ground together.

All curves of 3° or more had spiral approaches. These were allowed for in cross-sectioning by offsetting the slope stakes the required distance. The spiral was in standard form, so that, when the degree of curvature was known, the offset from the simple curve and the length of the spiral were obtained from tables. For simplicity and ease, all records, profiles, etc., were kept on simple curve data. When spiral curves came in tunnels, a special plan was made for each case, showing the offsets from the tangent and the simple curve at every 10 ft. on the spiral, the alinement being kept on the tangent and the simple curve, and allowing the required offset in giving the widths for the tunnels. All grades were compensated 0.04 ft. per degree of curvature.

Vertical curves were inserted at all places when the change of grade was more than 0.1 ft. in 100 ft., a standard form being used in which the length of the vertical curve varied directly with the change of grade.

The usual weekly reports, maps, and profiles were sent in by the assistant engineers. Standard forms were used for all notes, maps, profiles, plans and reports. The rules were first issued as typewritten copies, and forms were adopted from time to time as needed. Later, they were compiled and issued in book form, being blueprinted from tracings, making 22 pages of general rules and information, together with 24 standard forms for notes and plans. It was found to save much work and time in the chief engineer's office to have all data in uniform shape. Much correspondence was likewise avoided, as employees could readily find sizes, scales, etc., for plans, and also other information.

The greatest length of preliminary line run in one day

*In 220 miles there were 21 tunnels (the longest being 4,000 ft.) and five viaducts from 400 to 1,000 ft. long and more than 100 ft. high besides numerous bridges.

by one party was 7 miles, and of location, 4½ miles. The location averaged slightly over 1 mile per day per party, except that on the Burnsville & Eastern and Buckhannon & Northern lines; it averaged ¾-mile.

Stakes were set every 100 ft. on tangents, and every 50 ft. on curves. Special pains were taken with the instrument work and measurements, in order to avoid the chance of serious errors in the center line after construction commenced. The speed of location parties was usually limited by the amount of clearing that could be done, but the number of curves and the rough character of the ground were also large factors in limiting the speed. Each party cost from $35 to $40 per day, being allowed all expenses in addition to salaries.

Cost of Railway Surveys.

Table I. gives the cost per mile of the completed surveys. This is the total cost, and includes office rent, purchase of instruments and supplies, general expenses, all salaries, field expenses, and the preparation of final maps, plans, profiles, and estimates, with everything in readiness to make contracts for the line.

TABLE I.—COST OF COMPLETED SURVEYS.

Company.	Amount spent.	Miles of Surveys. Preliminary.	Location.	Total.	Average Cost. Per mile.	Per mi. of location.
L. Kan...	$25,076	428.19	193.85	622.04	$40.31	$129.36
Z., M. & P	19,812	509.03	105.23	614.26	32.25	188.28
B. & E...	20,466	241.75	113.70	355.45	57.58	180 00
P. B. & T.	6.651	84.56	38.17	122.73	54.20	174.28
B. & N...	19,249	162.51	151.29	313.80	61.34	127.23
Totals...	$91,258	1,426.04	602.24	2,028.28	$45.00	$151.53

The cost per mile of actual location includes preliminary lines. It will be seen that there were from 2 to 5 miles of preliminary lines run for each mile of location, except on the Buckhannon & Northern line. The table includes also 302 miles of check levels, the cost being distributed among the various accounts. The data for the Parkersburg Bridge & Terminal line include surveys and soundings for the Ohio River Bridge. The cost per mile includes the topography on practically all lines, except on the Zanesville, Marietta & Parkersburg line, where it was taken only on the located lines.

The cost shown in Table I., being the total charge against engineering from the inception of the project to the beginning of construction, contains a few items which might well be charged to other accounts than location. Instruments purchased could be a credit; some elaborate property surveys and bridge surveys could be charged to construction, but they probably are not large enough to have much effect on the cost per mile. If taken into account, they would reduct the cost.

The cost on the Little Kanawha and Burnsville & Eastern divisions was increased considerably owing to much work being done during a bad winter, when the weather was very unfavorable. The cost on the Parkersburg Bridge & Terminal line was increased by a large amount of property surveying in the city, and by the surveys for the bridge. The cost on all the West Virginia lines was increased by the immense amount of chopping and clearing necessary. When mountain laurel was encountered, all the axemen that could be worked could not keep a location party moving.

The influence of the weather is a large item in the cost of these surveys; a line run in the middle of winter may cost easily 25% more than if run during more favorable weather.

The average cost of one mile of preliminary or location survey, determined from a detailed study of the daily reports of field parties, of office work done, and similar data, is shown by Table II., and is believed to be very close to the actual figures. The figures include all expenses, as in Table I.:

TABLE II.—COST OF PRELIMINARY AND LOCATION SURVEYS.

Ry. Company.	Average Cost of One Mile: Of preliminary.	Of location.	Of location, including preliminary.
L. K.....	$25	$74	$99
Z., M. & P.....	23	79	102
B. & E.....	35	105	140
B. & N.....	31	94	125

Table I. shows a large variation in the cost of surveys on different divisions, the cost varying from $128 to $188 per mile, with an average of $151. On the assumption that lines located for comparison or similar purposes should be included in the average, one-third should be added to these amounts, as previously noted; the cost per mile would then be as follows: Low, $171; high, $251; average, $202.

Throwing out of the account the mileage of abandoned lines, branch lines, etc., and charging the entire cost to the main line, terminus to terminus, would give $91,258 / 328 = $278.23 per mile, which would be rather expensive. This, however, is not a fair assumption, and should not be considered, because many miles of lines not needed to determine the main line were located for other reasons and purposes. Therefore, the plan of throwing out only duplications, for comparisons, as shown in the preceding paragraph, gives the correct average cost per mile for the development of the country, including actual comparative locations where needed.

It should be borne in mind that a large proportion of this duplication was necessary, owing to the laws of West Virginia, which require an actual line, located on the ground, and a complete map and profile of that line to be filed with the Secretary of State, and at the county seat, before a railway company has any rights, of priority or otherwise, to that route of line. This required complete locations for all proposed branch lines, a large number of which were located, and also a complete location over any route for which it was desired to obtain rights. For these reasons, the lines located account for the excess of the mileage over the actual length of the main line.

On the basis of Table II., it may be assumed that, where the route has been previously determined within such narrow limits that the preliminary and location lines are of equal length, the surveys will cost from $100 to $140 per mile. This is borne out by the results on the Buckhannon & Northern line, where the location and preliminary lines were practically equal and the cost was $127 per mile.

These two statements may be combined in the following form:

(1) To locate one mile, including an equal length of preliminary lines, cost from $100 to $140; average, $115.

(2) To locate one mile, final location, including from two to five times as great a length of preliminary lines, cost from $128 to $188; average, $151.

(3) To locate one mile, final location, including from two to five times as great a length of preliminary lines, and one-third of a mile of location for comparison, cost from $171 to $251; average, $202.

A tabulation of the mileage of the Buckhannon & Northern line, with reference to the actual length of line to be built, and showing how the results agree with the averages deduced from Table I., is as follows, the Buckhannon & Northern line being used because the conditions there make it the best average of "all conditions" encountered on the various lines.

Total miles located.....		151.29
Miles of line.....	84	
Miles of connecting line located (but which may or may not be built)...	26	110.00
Making actual miles.....	110	
Leaving duplications, comparisons, etc....		41.29 miles.

110 miles cost $19,250 = $175 per mile.

All the work was carried out under S. D. Brady, M. Am. Soc. C. E., Chief Engineer of all the companies, who gave much personal attention to the work, and to whom the writer is indebted for assistance and information in preparing this paper. The writer was assistant engineer on the Little Kanawha Division, in charge of location; on its completion he became Assistant Chief Engineer of all the companies, both on location and construction.

Discussion.*

Mr. C. S. Bissell (Pennsylvania Ry.).—In making several surveys and locations along the south shore of Nova Scotia, it was found necessary to take contours only on the ruling grades and a few other points on the line. The grades were first cut through, and the profile taken (after the manner mentioned in this paper) from the summit downward. To accomplish this object, the transit was frequently carried several miles ahead of the measured line and set in the summit or other governing point, and the profile run from a temporary bench-mark, the elevation of which was assumed or estimated with a barometer. The measured line was then brought forward, connected, and run again over the maximum grade. Particular attention was then given to the contours and to the topography of the stream crossing which was usually found at the foot of the grade.

The great advantage in this method is the fixing of the proper point of connection at the foot of the grade with the assurance of passing through the governing point ahead. Notwithstanding the necessity of running over the grade twice, time is saved by avoiding much backing up and subsequent alteration of the line back of the foot of the grade. It gives a continuous chainage, saves much contouring, and produces a preliminary map which lies close to the location at all the critical points.

As to the maximum rate of progress per day mentioned in the paper (7 miles of preliminary and 4½ miles of location), I consider it excellent work for one party to accomplish even half these distances in one day.

Mr. F. Lavis (Pennsylvania Ry.).—The methods described in the paper agree very closely with those developed by me between 1898 and 1902 on the Choctaw, Oklahoma & Gulf Ry., and described in my paper.† Those surveys resulted in the construction of more than 800 miles of railway, and probably at least as many more miles of location were actually staked out on lines which were not built. It is probable that more [illegible] 5,000 miles of preliminary were run during that time.

During the last 10 or 15 years these general methods, with slight minor variations to suit local conditions and individual ideas, have become fairly well organized as standard on most of the large railway systems. At any rate, those engaged to any extent in building new lines and extensions, recognize the absolute necessity of such methods, in order to determine without doubt that the line finally adopted is such "that no other line can be built through the same country, with the same or better ruling grades, with less expenditure, at the same unit prices."*

The data relating to costs show close agreement with the costs presented in the paper referred to. In both instances they are somewhat higher than a great many locating engineers think their surveys have cost. But it will generally be found that, when these low costs are given, the fact has been lost sight of that the cost should include the field parties and a proper proportion of the expenses of the main and division offices, covering all work from the reconnaissance to the completion of the final maps and profiles, ready for the contractors to bid on the construction and the real estate agents to purchase right of way.

The costs of the field work of the preliminary and location lines agree very closely with those given in my own paper:

Cost.	McFetridge.	Lavis.
Ave. of preliminary, per mile	$28	$26
Ave. of location, per mile...	88	71
Ave. of completed location (on the basis of mileage of adopted location), per mile.	202	192
Field parties, per day.....	$35 to $40	$42 to $65 (ave. 46)

The somewhat lower cost of the field parties on the Little Kanawha Ry. (although the cost per mile of line was higher) is due probably to the difference in organization. On the C., O. & G. Ry., although all lines were subject to revision, of course, by the chief assistant engineer and the chief engineer, the locating engineers (whose whole expense, in addition to that of an assistant locator, was charged to the field party), were expected to be able to decide questions which, on the Little Kanawha Ry., were apparently not left to be settled by the assistant engineer in charge in the field.

The generally prevailing idea as to the cost of railway surveys is, that in the United States it should be about $100 per mile. In a review† of my book on "Railroad Location Surveys and Estimates," a well-known railway engineer made the statement that "much excellent location has been made in America in not easy country for less than $50 per mile of located line, and this cost includes the needed preliminary for that located line." I do not believe that any line, outside of a tangent across a prairie, and sometimes not even that, can be located and proper maps completed, for any such sum as he mentions, and that for any ordinary country a rough estimate of $200 per mile would be much nearer correct for properly conducted surveys and the preparation of a proper set of plans ready for construction, these latter, of course, not including details of structures.

The trouble with most of the published cost of location surveys is that they do not include anything but the cost of staking out a location on the ground; and supervision, office expenses, equipment, costs of preparation of proper maps, profiles, etc., are omitted.

One very important rule in regard to the final location should be made inflexible: After the profile of the located line has been plotted, a temporary grade line fixed, tentative determinations of bridges, culverts, etc., made, and preliminary quantities calculated and distributed (this latter being most important), the locating engineer should take the profile into the field, and, walking over the line, should study carefully the situation on the ground in the light of the information which he then has, which, by that time, should be almost complete. This final review, if conscientiously done by a competent man, will often save many thousands of dollars in the construction, and avoid costly mistakes.

Mr. McFetridge, although he evidently prefers the separate-sheet method, recognizes the necessity of having a large rolled map of the whole line in order to get a comprehensive view of the whole situation. His very positive statement that the separate-sheet method of obtaining topography is quicker and better than any other is open to argument.

The fundamental idea of the proper principles governing the staking out of the located line is stated very concisely by the author:

In staking out the location, the aim was to get a profile to correspond with the projection, and not to get the lines in exactly the same relative positions shown by the projections.

In other words, there is to be no slavish following of the projected location as a line on the map, but rather to reproduce, on the ground, the line which the studies of the map and the general situation have shown is there, and is the best. It is just here that modern methods differ from the old. It is neither the old paper location made

*Condensed from the "Proceedings" of the American Society of Civil Engineers, August, 1909.

†Transactions, Am. Soc. C. E., Vol. LIV. (1905).

*"Railway Location Surveys and Estimates," Lavis (p. 8).

†"Technical Literature," April, 1907.

without reference to conditions in the field, nor the work of the genius who threw his curves at the hills, as the cowboy throws his rope at a steer, and sometimes hit them and sometimes missed.

The modern method collects all the available data affecting the location, eliminates definitely the unavailable lines, projects on the map the line which best fulfills all the requirements of the situation, and then uses all the intelligence of the genius in reproducing that line on the ground. No extraordinary mathematical calculations are required to lay out the located line from the projection, only plain common sense and locating skill.

No amount of accuracy in making the original surveys and plotting the map can compensate for lack of intelligence in transferring the projection to the ground; and extreme refinement of accuracy is wasted if proper intelligence is used.

One other important point brought out in the paper is that actual surveys of all possible routes were made. As the author points out, this does not mean that an indiscriminate topographical map of the whole country was made, or was necessary. In spite of all that has been written about eliminating certain routes by eye (and perhaps by a hand-level), there is no question that absolute proof, by actual survey, should be furnished to the people putting up the money (or responsible for its expenditure) that there is no doubt that the location adopted is the best posible under the given governing conditions. The ability and so-called "eye for country" ascribed to the older generation of locating engineers, which many of them undoubtedly possessed, are just as necessary to-day, but must be supplemented by scientific methods, adequate surveys, and much hard work. This is necessary, not only in order to be able to furnish proof that the line adopted is the best, but generally in order to find this line.

It used to be not uncommon to hear the genius with "eye for country" (and not much else) talk about the foolishness of trying to get a line of 0.5% through a 1% country. The results obtained by these surveys form only another instance of the possibility and practicability of finding these lines if one knows how to look for them. This description of work actually accomplished should be borne in mind by all who have to obtain money for such surveys, and should serve to stiffen their backbones in demanding all that is necessary to carry out such surveys in an adequate manner.

Mr. E. W. Lewis (N. Y., N. H. & H. Ry.).—The costs given in the paper, are interesting as showing the wide differences on various lines. The approximate costs of some surveys in various parts of the country may be of interest. On the north bank of the Columbia River, in Washington, over rough, difficult ground, largely on steep slopes, with numerous short tunnels, where, in some instances, it was necessary to lower men down the cliffs with ropes in order to get the line staked, the cost for a stretch of 32 miles was about $325 per mile.

In Massachusetts, through an average country, largely wooded, the cost of 20 miles of location was about $150 per mile. In North Dakota, 60 miles of location over a rolling prairie, and crossing one deep, broad valley, cost $110 per mile. In another section of the same state, over rolling prairie, the cost was $80 per mile. These figures are for the total cost of the final location, including all preliminary, trial and abandoned lines.

Mr. Geo. L. Dillman.—No two locations are alike, and hardly any two are comparable in time, cost or value. Two locations are worth noting as being extremes in practice: The first was in Cottonwood Canyon, on the Grand River in Colorado, between Dotsero and Glenwood Springs. Afterward the Denver & Rio Grande Ry. built its line on the opposite side of the canyon. There was a great deal of clearing, and the topography was such that direct measurement was often impossible, so that a great deal of triangulation for distance was necessary. This location cost more than $600 per mile.

The second location was on the North Platte River, in Nebraska, extending more than 100 miles northwest from North Platte. The country was open, there was no clearing, the tangents averaged about nine miles, and the curve angles between them were small. This location cost between $17 and $18 per mile.

These locations were each fully staked on the ground. The costs include maps, profiles and computed estimates, as well as all preliminary work. The parties had about the same number of men and equipment, except that more axe-men were added to the Grand River party. Each party worked efficiently and sometimes for long hours. If there was any difference, the cheaper location was the more carefully made. Tracings of each map were filed with the Department of the Interior, accompanying applications for rights of way across government land, and each location was ready for the construction crews.

These locations are probably not extremes; there may have been cheaper locations made; undoubtedly, there have been more expensive ones. What is desired is to bring out the fact that there is no possible connection between the costs of railway locations; and that a full knowledge of the cost in one case cannot be applied to any other case.

Comparative Tests of Carbon and High-Speed Tool Steels.

High-speed tool steels, according to tests described in a paper recently read before the Manchester (England) Association of Engineers, are decidedly inferior to ordinary carbon steel for light cuts and slow speeds. In some instances, tools of carbon steel lasted four times as long as exactly similar tools of high-speed steel under the same cutting conditions. These results should have some effect on the tendency to regard high-speed steel as superior for all sorts of cutting tools, even including hand tools, such as files and reamers.

The tests were made by means of a special tool-steel testing machine which may also be used for wear or hardness tests. It somewhat resembles a light drill-press in general appearance, having a vertical column that carries the driving mechanism and the bearing for the vertical shaft, or spindle. A horizontal table extends from the column below the lower end of the spindle and carries the tool vise and the scale beam for determining the pressure of the cut. The tool is held stationary in the vise and the cutting is done upon a cylinder of soft steel attached to the revolving spindle above the tool.

The lower edge of the rotating tube is supported by a small bracket arm extending from a projection on the table and, as the tube is cut away, it is fed down against this support by a weight attached to the spindle, so that the position of its lower edge is kept constant. The tubes used have an outside diameter of ¾-in. and a bore of ⅝-in. The tool vise is carried by the short end of a steelyard supported on a knife edge and, by means of a weight sliding on the graduated arm of the steelyard, the tool may be made to exert any desired definite pressure against the end of the tube. A dashpot is connected to keep the tool from chattering.

The recording apparatus consists of a paper-covered drum, which revolves with a speed proportional to that of the shaft, and a pencil point which has a vertical motion proportional to the downward feed of the spindle as the tube is cut away. Thus, the line traced on the drum by the pencil has a slope which represents the rate of cutting in fractions of an inch per revolution.

In the paper referred to, by Mr. Edward G. Herbert, of London, appears the following discussion* of tests made with this machine:

It has already been shown that the slope of the curve drawn by the machine indicates the rate at which the test tube is being cut away by the tool, and it is evident that this rate is governed by several factors; the speed and quality of the test tube, the shape and position of the tool, and the force with which it is pressed against the tube. Any alteration in any one of these factors will affect the rate of cutting and the slope of the curve, which, therefore, serves as an absolute check on the uniformity of the mechanical conditions. The remaining factor in the test is the quality of the tool, and a moment's consideration will show that this does not affect the rate of cutting at all. So long as a number of tools are equally sharp, they will all cut at the same rate under the same conditions, no matter what steel they are individually made of.

But the tool which is made of the best steel will remain sharp longest. Loss of sharpness will take place continuously from the commencement of the test until the pressure of the tool against the tube is no longer sufficient to cause it to penetrate the metal. When this definite degree of bluntness is attained the vice will slightly tilt on the knife edges which support it, and the tool will slip over the surface of the tube without further cutting. This is shown on the diagram by the curve becoming a horizontal straight line. The number of revolutions made by the tube before this slipping takes place is a measure of the quality of the tool steel, and it was anticipated that this cutting quality or durability of any steel could be expressed by a simple number of revolutions just as the tensile strength of the same steel can be expressed in tons per square inch.

The first series of tool steel tests was made with a view to comparing the cutting properties of a good brand of high-speed steel with those of an ordinary carbon tool steel. Both tools cut at the same rate, as anticipated, but the carbon lasted four times as long as the high-speed steel. The result was disconcerting.

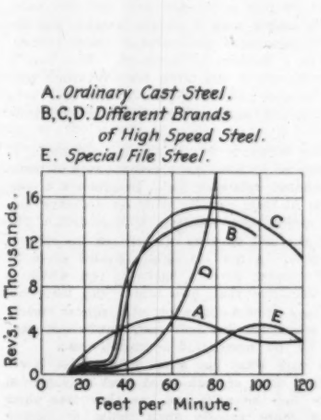

Fig. 1. Durability-Speed Curves.

(Ordinates show number of revolutions made by tube before tool refused to cut.)

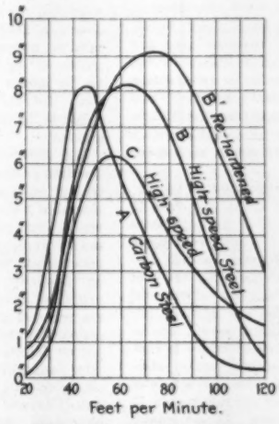

Fig. 2. Equal-Wear-Speed Curves.

(Ordinates show length of tube cut away before edge of tool had worn down 0.003-in.)

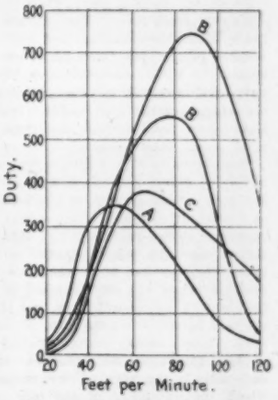

Fig. 3. Duty-Speed Curves.

(Ordinates show the product of the ordinates and abscissas of the curves in Fig. 2 for the different cutting speeds.)

FIGS. 1, 2 AND 3. CURVES COMPARING THE CUTTING QUALITIES OF HIGH-SPEED AND CARBON TOOL STEELS AT VARIOUS CUTTING SPEEDS.

The tests were repeated, the high-speed tool was re-hardened, and other high-speed steels were tested, but always with similar results; the carbon steel did several times as much work as any of the high-speed steels. Before definitely deciding whether to scrap all the high-speed steel in the works, or to scrap the testing machine, it was resolved to repeat the tests under altered conditions, and the speed of the test tube was increased from 30 to 40 ft. per minute. The result was that the high-speed steel lasted 8,000 revolutions of the test tube, and the carbon steel only 4,000.

The next step was to make a series of tests with the same tool, varying the speed step by step, but keeping all the other conditions the same. The tool was of carbon steel, ground with 0° rake and 20° clearance, and pressed against the test tube with a force of 15 lbs. Several points about these results will at once attract attention as being apparently at variance wih every-day experience. As the speed was increased the tool cut faster (per revolution), it did more work, and lasted longer, while at the lowest speed of all—12 ft. per minute—it did not cut at all. These are not peculiarities of one particular tool, but are common to all tools of whatever steel, under the conditions of the tests.

The greater total amount of metal removed at the higher speeds, before the tool became blunt is due to the fact that a tool which is too blunt to continue cutting at a slow speed will cut quite freely when the speed is increased. A tool was tested until it ceased cutting at 40 ft. per minute; the speed was then increased to 85 ft. per minute, and the same blunt tool immediately began cutting faster (i. e., removing more metal per revolution) than when it was quite sharp and working at the lower speed.

There is, then, a definite state of bluntness, corresponding to each speed, at which cutting ceases. Below a certain limiting speed (depending on the pres-

*From an abstract in the "Iron and Coal Trades Review" of a paper on "The Testing of Files and Tool Steel" read March 27, 1909, before the Manchester Association of Engineers.

sure used) a perfectly sharp tool will not cut at all. At a slightly increased speed it will continue cutting until a few thousandths of an inch are worn off the edge. At a higher speed still it will continue cutting with undiminished efficiency until quite a deep hollow is worn in the edge.

Description of Tests.

A series of tools was made from different brands of steel, including several well-known high-speed steels and a good carbon steel. All were ground alike with 0° rake and 20° clearance, and all were tested until they ceased to cut, at speeds gradually rising from 12 ft. per minute (at which none of the tools would cut at all), the pressure being in all cases 15 lbs. The results of all the tests were then plotted out in a diagram, Fig. 1, in which vertical distances represent the number of revolutions made by the test tube before cutting ceased, and horizontal distances represent cutting speeds in feet per minute.

These curves bring out in a striking manner the behavior of the high-speed steels at low cutting speeds, in contrast with the behavior of the carbon steel under the same conditions. The type of curve is essentially different for the two classes of steel, and it is not until we reach the speed of 36 ft. per minute that the best of the high-speed steels shows a lasting power equal to that of the carbon steel. At higher speeds the position is reversed, and the high-speed steels justify their name.

It must by no means be assumed that all alloy steels are inferior to carbon steel for file making; there is good reason to believe the contrary, but it is evidently unsafe to assume that because a certain steel has given good results in, say, twist drills, it must therefore be suitable for cutting tools which are used under totally different conditions. For instance, reamers are now made of highspeed steel, and are usually stated by the makers to do "ten times as much work as an ordinary reamer." What constitutes an "ordinary reamer," and how much work it will do, is not usually stated. Reamers are generally used under a light scraping cut at a slow speed, precisely the conditions for which high-speed steel seems least suited.

The curves in Fig. 1 give a true comparison of the behavior of different steels at any given speed, but they do not give a true account of the behavior of any one steel at different speeds. A series of equal-wear-speed curves is shown in Fig. 2. In this diagram vertical distances show the length of tube turned away by the tool before its edge had been worn down $^{3}/_{1000}$-in. Horizontal distances show the cutting speed in feet per minute. The feed was in all cases 1.2 ins. per thousand revolutions of the test tube. The true form of the speed curve is now seen. Here, again, the superiority of the carbon steel at low speeds is very marked, and what is specially noticeable is the very narrow range of cutting speeds at which the durability of the tool is near its maximum. It will at once be said that the results are in one respect at variance with actual experience of cutting tools, since any tool will keep its edge longer at a low cutting speed of, say, 20 ft. per minute, than at a speed of 40 or 50 ft. per minute. Given certain working conditions, this is a fact, but one which is not at all inconsistent with the present results, as will be explained later.

The equal-wear-speed curve clearly shows which speed will enable a given steel to remove the maximum amount of metal without sharpening, but it gives no direct account of the time required to do the work. In practice we do not require to know at what speed the tool will last longest, but what are the conditions, consistent with reasonable durability of the cutting tool, which will give the maximum output of work per hour. To obtain this information it is necessary to multiply the total number of inches turned off the tube at each speed by the corresponding cutting speed. The product is a quantity—which may be termed the "duty" of the tool—which is directly proportional to the durability of the tool and to the time rate of removing metal, and it is reasonable to assume that when the duty attains a maximum, the ideal working conditions have been reached.

In Fig. 3 are shown the duty curves derived in the manner described from the equal wear speed curves A, B, B', C, Fig. 2. A comparison of the duty curves B, B', C (Fig. 3) of the high-speed steels, with the duty curve A of the carbon steel, gives a correct impression of superiority of high-speed steel for the rapid removal of metal. The peak of the duty curve coincides with the ideal cutting speed for the steel in question, and this speed is always higher than the speed of maximum durability indicated by the peak of the speed curve.

Testing the Wear of Metals.

Another application of the tool steel testing machine is that of ascertaining the wear-resisting properties of metals. In these tests the usual test tube is replaced by a tube of hardened steel with a perfectly smooth, flat edge. The specimen to be tested takes the form of a plate about one-sixteenth of an inch thick, which is held in a vertical plane in a special vice. The edge of the tube rests on the edge of the specimen, and when the machine is set in motion passes across it transversely so as to wear a groove, the depth of which is registered on the diagram, together with the number of revolutions made by the tube. The load is adjusted by weighing the spindle. The rate of wear is conveniently expressed in inches per 100,000 revolutions, and is given by the slope of the straight line drawn by the pencil.

A number of tests were made to ascertain the relation between the lead on two surfaces in rubbing contact and the amount of wear produced. In these tests a hard steel tube was used in conjunction with a plate of mild steel, the lubricant being water. The wear diagram is a straight line passing through the origin. When the load is increased beyond a certain point a sudden increase takes place in the rate of wear, as shown by the abrupt change in the direction of the wear diagram. It thus appears that steel shows a very marked "wear yield point," similar to the yield point in tension, and it may be found that there is a definite relation between the wear yield point and the tensile yield point in the same material. In the particular steel under examination the wear yield point was 16,600 lbs. per square inch. The tensile yield point was not determined, but would probably be about double this figure.

It remains to be determined whether, and to what extent, the position of the wear yield point is affected by changes in the speed at which rubbing takes place, and this investigation may throw additional light on the phenomena connected with the wear of cutting tools, and their more or less rapid failure at different cutting speeds.

Testing the Hardness of Materials.

One other function of the tool steel-testing machine may be mentioned, though it is only indirectly connected with the subject of this paper—the drill test for hardness. A drill is loaded with a certain weight, and the rate at which it penetrates the material under investigation is used as a measure of hardness. This test is by no means new, but it has often been regarded with some distrust, because the sharpness of the drill is a variable factor in the result of the test as ordinarily applied.

The distributing influence of the varying sharpness of the drill is eliminated by adopting a definite rate of penetration on a standard reference bar. In practice a considerable number of tests can be made on ordinary materials without perceptible blunting of the drill. The sensitiveness of the test depends entirely on the rate of penetration adopted. A drill so lightly loaded as to be on the point of slipping gives a hardness test which is probably more sensitive than any other, and materials are rejected if they show a difference of hardness clearly perceptible by means of the drill test, but which cannot be detected by the indentation or impact tests.

In connection with what has gone before it is interesting to note that drills of high-speed steel have proved quite unsuitable for the drill test, as they lose their sharpness much more rapidly than drills of carbon steel, under the extremely light cuts that are essential for a sensitive test.

A LARGE MINE HOIST was recently installed in the colliery of the Washington Coal & Coke Co., at Dawson, Pa., by the Connellsville Manufacturing & Mine Supply Co., having several interesting features.

The hoist is used 800 ft. below the surface, to haul 35 mine cars, averaging 3,800 lbs. each, loaded, up a maximum grade of 8.5%, 8,000 ft. long at a speed of 600 ft. per min. The loaded cars start at the bottom of the slope on a 4% grade, which gradually increases till the maximum grade of 8.5% is reached near the top, where the loaded cars are pulled in at a landing on a grade of about 6% and on a curve of 150 ft. radius. The empty cars will be allowed to drift down the slope by gravity controlled by a brake on the hoist drum. The hoisting drum is 6 ft. in diameter and 5 ft. wide between flanges, and is fitted with a hand brake on one end and a hand-operated friction clutch on the other end. The hoist is driven, through a flexible connection, by a 500-HP. direct-current, compound-wound, non-reversible motor. This is controlled by three magnetically operated unit switches which are in turn operated by a hand controller, carrying only small currents as the main-motor current is handled by the unit switches. Thus difficulties from arcing at the controller are eliminated. There is provided also an acceleration relay which prevents the starting switches from closing too rapidly. The second switch cannot close until the current allowed to flow by the closing of the first has fallen to a predetermined value. As soon as this value is reached the second switch closes thereby short circuiting a resistance section and the current rises, but the third switch cannot close until the current has again fallen to the predetermined value. This not only prevents injury to the motor from careless handling during acceleration, but also insures the most rapid automatic starting possible. The controller also has a safety relay which opens the resistance switches in cases of excessive overload, and thereby protects the motor while running. If this relay operates while the motor is running, the motor does not stop but is automatically brought up to its full speed again. The electrical apparatus was built by the Westinghouse Electric & Manufacturing Co., of Pittsburg.

Tests of Plain and Reinforced-Concrete Columns.*

By M. O. WITHEY.†

This paper reports tests on plain and reinforced-concrete columns made in the laboratory for testing materials at the University of Wisconsin during the past year.

KINDS OF COLUMNS.—Preliminary tests were first made, upon 20 columns of the following five classes: 1, plain concrete; 2, columns reinforced with latticed angle structural-steel columns; 3, columns reinforced with high-carbon steel spirals; 4, columns reinforced with spirals and vertical steel rods; 5, columns reinforced with vertical steel rods and ties a foot apart. A more extended series of tests was then made on 32 columns containing spiral reinforcement, the variables being percentage of vertical steel, percentage of spiral steel and richness of mix.

MATERIALS.—Atlas Portland cement was used in the preliminary tests and Universal in the remainder. Both were tested and passed the specifications of the American Society for Testing Materials. A local pit furnished a rather fine but fairly clean sand. It weighed about 107 lbs. per cu. ft. and contained 36% voids. Crushed limestone was secured from a nearby quarry. In making columns G1 to N2, stone passing a 1-in. screen was used. This weighed 82 lbs. per cu. ft. and contained 50% voids. In all other columns where stone was used, the size was less than 1¼ ins., the weight 92 lbs. per cu. ft. and the percentage of voids 44.

Concrete was proportioned by volumes, measured loose, cement being assumed to weigh 100 lbs. per cu. ft. Volumes were measured by weighing. All concrete

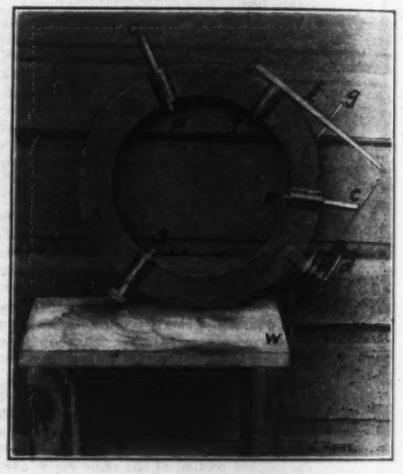

Fig. 1. Ring Apparatus for Measuring Lateral Expansion of Column.

was mixed for about three minutes in a No. 0 Smith mixer. After the dry materials had been thrown in and turned for about a half minute, water was admitted from a calibrated tank to both the mouth and hopper of the mixer. About 10% of the total weight of dry materials was found necessary to give a wet concrete which would easily flow around the reinforcement.

Tensile tests of the steel reinforcement showed yield-point 38,100 to 47,400 for the rods, and 81,000 to 104,500 for the wire. One steel column of the same dimensions as those used to reinforce columns B1 to B4 was tested and showed an elastic limit of 33,400 lbs. per sq. in., an ultimate strength of 48,000 lbs. per sq. in. and modulus of elasticity of 26,000,000 lbs. per sq. in.

FABRICATION.—All columns with the same letter were made on the same day, care being taken to keep all conditions as uniform as possible. All columns of the preliminary series, A1 to F1, were 10 ft. long. The reinforced columns of this series were all made with a protective shell 1 or 2 ins. thick. In order to study the behavior of this shell and its effect on the strength of the test-piece, it was removed from columns B1, B1 and C1 before testing. The remaining columns were 8½ ft. long. As the shell outside of the spiral added very little to the strength of the column, only the core area has been considered in computing stresses for these columns.

All vertical reinforcement was milled to the required length.

The columns of the preliminary series were made in wooden forms; all others were cast in molds of galvanized iron. These forms were set upon planed cast-iron bed-plates which were carefully leveled before the

*A paper read before the American Society for Testing Materials, at Atlantic City, June 28-July 3, 1909.

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columns were poured. A compression cylinder 6 ins. in diameter and 18 ins. long was cast in an iron mold from every batch of concrete. A day or two after pouring, columns and cylinders were capped with a thin layer of 1:1 mortar. While the mortar was still soft, a cast-iron end-plate was placed upon it and carefully leveled. The depth of the mortar over the ends of the vertical reinforcement was made as small as possible. After six days forms were removed from the specimens. They were then wet twice a day for one week, after which they were sprinkled once a week until tested. The age at which specimens were tested varied from 50 to 65 days.

TEST METHOD.—Columns were tested in the 600,000-lb. hydraulic testing-machine in the laboratory. The lower head of this machine is rigidly fixed to the piston rod of a hydraulic jack, while the upper head is free to adjust itself to a specimen through a ball-and-socket joint. Columns were bedded at each end on cast-iron plates covered with a thickness of blotting paper.

Stresses were applied at the rate of approximately 200 lbs. per sq. in. per min., the increments of load being in general 15,000 lbs. Longitudinal deformations were measured on four sides of a column by means of copper wire dial compressometers. Readings were taken to .0001-in. over gage lengths of 66 ins. for the 8½-ft. columns and 80 ins. for the 10-ft. columns.

Measurements of lateral deformations at the middle of a column were made on columns G2 to W3 by means of a ring-shaped apparatus, shown in Fig. 1. The main part of one of these devices consisted of a welded steel ring which encircled the column and was held in position by the pivots *pp* and the screw *s*. The pivots *pp* rested against springs coiled in the cylindrical cups *cc*. Screws in the ends of these cups served to regulate the pressure of the springs upon the pivots. These springs took up the swelling of the column without disturbing the position of the ring vertically. As a 1-lb. force deformed a spring about 0.01-in. and the same force applied along a diameter would deform the ring only 0.000003-in., it will be seen that the change in dimensions of the ring during a test was negligible. The deformation between the screw *s* and the sliding point *f* was multiplied five times by the lever *l* and transmitted to the dial *d* through a No. 36 covered copper wire held taut by the weight *w*. The guide *g* afforded a knife-edge support for the aluminum lever *l* to slide upon. A careful calibration of this device showed that it was quite sensitive and that the probable error of a single observation was less than 5%.

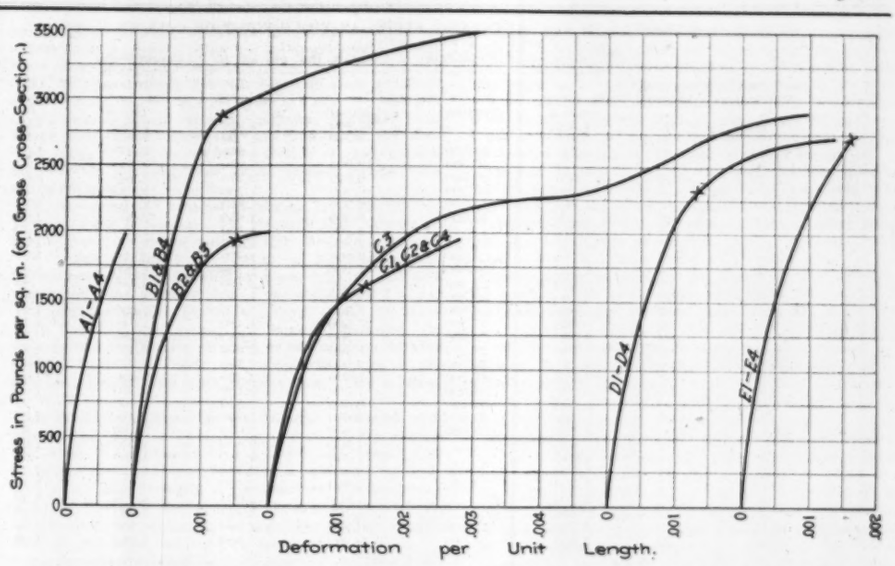


FIG. 2. AVERAGED LOAD-COMPRESSION CURVES FOR PRELIMINARY SERIES OF CONCRETE COLUMNS.

(See Table I. for amount and kind of reinforcement.)

RESULTS OF TESTS.—Only a brief discussion of main features of the tests will follow. The chief figures obtained from the tests are set forth in Table I.

TABLE I.—RESULTS OF TESTS OF COLUMNS AND SMALL TEST-CYLINDERS.

A1 to F1, Preliminary Series.
H1 to W3, Final Series.
Columns Tested at Age of Two Months.

Col. No.	Reinforcement.	Per cent. reinforcement. Vertical.	Lateral.	Mix.	Shape of cross section.	Area, sq. in.	Ultimate strength, lbs./in².	Stress at yield-point, lbs./in² in gross section.	Ratio Yld.-Pt. to Ult.	Compressive strength of cylinders, lbs./in².	Modulus of Elast. at ¼ Ult. Str., millions lbs./in².	Poisson's ratio at ¼ Ult. Str.	$\frac{E_s}{E_c} = n$ At ¼ Ult. Str.	$\frac{E_s}{E_c} = n$ At yield-point.
A1	None.	0	0	1-2-4	Square	144	2,040	....	...	2,430	...	...	..	..
A2	None.	0	0	"	"	143	2,110	....	...	2,400	...	...	..	..
A3	None.	0	0	"	"	142	2,055	....	...	2,240	...	...	..	..
A4	None.	0	0	"	"	141	2,080	....	...	2,360	...	...	..	..
*B1	4—2" x 2" x 3/16" latticed angles.	4.5	..	"	"	64	3,700	2,860	.77	2,270	...	...	..	..
*B4		4.5	..	"	"	64	3,780	2,860	.76	2,140	...	...	..	..
B2		2.0	..	"	"	143	2,125	1,920	.90	2,640	...	...	..	..
B3		2.0	..	"	"	143	2,015	1,960	.97	2,200	...	...	..	..
C1	¼-in. spiral, 1-in. pitch.	0	1.33	"	Octagonal	118	4,660†	1,800	.58	2,280	...	...	..	..
C2		0	1.33	"	"	118	4,390†	1,550	.53	2,190	...	...	..	..
*C3		0	2.00	"	Round	78.5	3,660†	1,950	.53	2,180	...	...	..	..
C4		0	1.33	"	Octagonal	118	3,410†	1,550	.68	2,150	...	...	..	..
D1	9—⅝-in. rods and ¼-in. spiral, 1-in. pitch.	2.35	1.33	"	"	118	4,470†	2,180	.74	2,150	...	...	..	..
D2		2.35	1.33	"	"	118	4,200†	2,310	.83	2,130	...	...	..	..
D3		2.35	1.33	"	"	118	4,970†	2,560	.77	2,380	...	...	..	..
D4		2.35	1.33	"	"	118	5,360†	2,440	.68	2,350	...	...	..	..
E1	9—⅝-in. rods with ¼-in ties, 1 ft. c. to c.	2.35	0.11	"	"	118	2,310	2,310	1.00	2,430	...	...	..	..
E2		2.35	0.11	"	"	118	2,310	2,310	1.00	2,430	...	...	..	..
E3		2.35	0.11	"	"	118	2,695	2,695	1.00	2,040	...	...	..	..
F1	None.	0	0	"	Square	118	1,880	....	...	2,230	...	...	..	..
H1	No. 7 wire spiral, 2-in. pitch	0	.46	1-2-3½	Round	78.5	2,330	1,950	.84	2,040	2.5	.14	12	24
H2		0	.46	"	"	78.5	2,140	1,760	.82	1,460	2.2	.114	14	30
G1	8—½-in. rods & No. 7 wire spiral, 2-in. pitch.	2.00	.46	"	"	78.5	3,320	2,710	.82	2,100	3.3	.11	11	21
G2		2.00	.46	"	"	78.5	3,280	2,710	.83	1,420	3.4	.11	11	21
I1	8—11/16-in. rods & No. 7 wire spiral, 2-in. pitch.	3.78	.46	"	"	78.5	4,240	3,660	.87	2,240	3.7	.14	11	18
I2		3.78	.46	"	"	78.5	4,080	3,280	.80	2,120	3.1	.08	15	26
J1	8—⅞-in. rods & No. 7 wire spiral, 2-in. pitch.	6.11	.46	"	"	78.5	5,190	4,240	.82	2,110	4.5	.09	11	22
J2		6.11	.46	"	"	78.5	5,050	4,240	.84	2,000	4.2	.085	12	22
L1	No. 7 wire spiral 1-in. pitch.	0	.92	"	"	78.5	2,680	1,370	.51	1,780	2.2	.153	14	19
L2		0	.92	"	"	78.5	2,600	1,370	.53	1,760	2.0	.137	15	20
K1	8—½-in. rods & No. 7 wire spiral, 1-in. pitch.	2.00	.92	"	"	78.5	4,050	2,710	.67	2,100	2.9	.110	13	20
K2		2.00	.92	"	"	78.5	3,760	2,520	.67	1,890	2.7	.135	14	23
N1	8—11/16-in. rods & No. 7 wire spiral, 1-in. pitch.	3.78	.92	"	"	78.5	4,050	3,470	.86	1,880	4.05	.100	10	18
N2		3.78	.92	"	"	78.5	4,340	3,280	.76	1,720	3.55	.16	12	22
M1	8—⅞-in. rods & No. 7 wire spiral, 1-in. pitch.	6.11	.92	"	"	78.5	4,790	3,880	.81	1,660	3.05	‡.083	‡23	23
M2		6.11	.92	"	"	78.5	4,580	3,660	.80	1,710	3.8	.118	14	25
P1	8—1-in. rods & No. 7 wire spiral, 1-in. pitch.	8.00	.92	1-2-4	"	78.5	6,760	5,580	.82	2,380	5.2	.123	9.9	15
P2		8.00	.92	"	"	78.5	7,090	5,760	.81	2,350	5.4	.119	9.2	14
O1	8—⅞-in. rods & ¼-in. spiral, 1-in. pitch.	6.11	1.96	"	"	78.5	6,510	4,240	.65	2,270	4.6	.129	10	17
O2		6.11	1.96	"	"	78.5	6,650	4,620	.70	2,090	4.7	.132	9.8	15
R1	8—1-in. rods & ¼-in. spiral, 1-in. pitch.	8.00	1.96	"	"	78.5	7,250	5,090	.69	2,310	5.25	.117	9.8	17
R2		8.00	1.96	"	"	78.5	6,680	5,380	.80	2,460	5.25	.138	9.8	15
Q1	8—1⅛-in. rods & ¼-in. spiral, 1-in. pitch.	10.12	1.96	"	"	78.5	6,190	5,190	.84	2,280	5.2	.088	12	19
Q2		10.12	1.96	"	"	78.5	7,990	6,340	.79	2,330	5.8	.101	9.8	15
S1	No. 7 wire spiral 1-in. pitch.	0	.92	1-1-2	"	78.5	5,950	3,860	.65	4,060	3.9	.151	7.7	10
S2		0	.92	"	"	78.5	5,760	4,240	.74	4,080	4.35	.117	6.9	8.8
T1	8—⅞-in. rods & No. 7 wire spiral, 1-in. pitch.	6.11	.92	"	"	78.5	7,480	5,760	.77	4,720	5.35	.15	8.0	9.9
T2		6.11	.92	"	"	78.5	7,100	5,760	.81	4,080	5.0	.134	8.9	10
V1	No. 7 wire spiral 1-in. pitch.	0	.92	1-1½	"	78.5	5,760	3,660	.64	4,820	3.4	.156	8.8	10
V2		0	.92	"	"	78.5	4,920	3,480	.71	4,930	3.4	.113	8.8	11
U1	8—⅞-in. rods & No. 7 wire spiral, 1-in. pitch.	6.11	.92	"	"	78.5	8,050	5,950	.74	4,900	5.5	.143	7.7	8.8
U2		6.11	.92	"	"	78.5	8,250	5,950	.72	4,210	5.0	.106	8.9	9.6
W1	None.	0	0	1-2-4	"	86.6	2,660	....	...	2,600	3.7	.137	8.1	..
W2		0	0	"	"	86.6	2,660	....	...	2,400	3.6	.112	8.3	..
W3		0	0	"	"	86.6	2,480	....	...	2,250	3.2	.095	9.4	..

*Outside shell removed before testing.

†Ultimate strengths for columns C1 — D4 = $\frac{\text{maximum load}}{\text{core area}}$.

‡A load of 300,000 lbs. was accidentally applied before test was begun.

TABLE II.—STRESSES IN CONCRETE AND STEEL AT YIELD-POINT OF COLUMN.
(Columns of Final Series.)

Col. No.	Reinforcement Vertical %	Reinforcement Lateral %	Stresses of Yield-Point of Column, lbs. per sq. in. In gross section.	In steel Vertical.	In steel Lateral.	In concrete (f_c)	Compressive strength of cylinders, lbs./in.² (C)	$\frac{C}{f_c}$
H1	0	.46	1,950	.....	11,400	1,950	2,040	1.05
H2	0	.46	1,760	.....	8,700	1,760	1,460	.83
G1	2.00	.46	2,710	40,500	....	1,940	2,100	1.08
G2	2.00	.46	2,710	40,500	12,000	1,940	1,420	.73
I1	3.78	.46	3,660	40,500	6,900	2,220	2,240	1.01
I2	3.78	.46	3,280	43,500	6,000	1,700	2,120	1.25
J1	6.11	.46	4,240	40,500	6,300	1,870	2,110	1.13
J2	6.11	.46	4,240	40,800	6,000	1,850	2,000	1.08
L1	0	.92	1,370	.....	4,800	1,370	1,780	1.30
L2	0	.92	1,370	.....	4,800	1,370	1,760	1.28
K1	2.00	.92	2,710	39,000	6,900	1,970	2,100	1.07
K2	2.00	.92	2,520	39,900	7,200	1,760	1,890	1.07
N1	3.78	.92	3,470	37,500	6,300	2,130	1,880	.88
N2	3.78	.92	3,280	39,900	7,500	1,840	1,720	.93
M1	6.11	.92	3,860	38,100	5,400	1,650	1,660	1.01
M2	6.11	.92	3,660	37,200	7,500	1,480	1,710	1.16
P1	8.00	.92	5,560	39,300	7,500	2,630	2,380	.91
P2	8.00	.92	5,760	39,000	8,700	2,870	2,350	.82
O1	6.11	1.96	4,240	36,600	9,000	2,130	2,270	1.07
O2	6.11	1.96	4,620	37,200	7,800	2,490	2,690	1.08
R1	8.00	1.96	5,000	36,900	7,500	2,230	2,310	1.04
R2	8.00	1.96	5,380	38,100	9,000	2,540	2,460	.97
Q1	10.12	1.96	5,190	35,400	6,600	1,790	2,280	1.27
Q2	10.12	1.96	6,340	39,000	6,900	2,670	2,330	.87
S1	0	.92	3,860	.....	7,500	3,860	4,060	1.05
S2	0	.92	4,240	.....	7,200	4,240	4,080	.97
T1	6.11	.92	5,760	36,900	6,900	3,730	4,720	1.27
T2	6.11	.92	5,760	37,200	7,800	3,720	4,080	1.10
V1	0	.92	3,660	.....	7,800	3,660	4,820	1.32
V2	0	.92	3,480	.....	5,700	3,480	4,930	1.42
U1	6.11	.92	5,950	35,400	6,900	4,040	4,900	1.21
U2	6.11	.92	5,950	37,500	6,900	3,900	4,210	1.08

PLAIN COLUMNS.—The 1:2:4 plain concrete columns A1 to A4 had an average ultimate strength of 2,070 lbs. per sq. in., the maximum variation from this value being only 2%. Plain columns W1 to W3, also of 1:2:4 mix, were exceptionally strong for the class of materials employed and showed an average ultimate strength of 2,600 lbs. per sq. in. As these three columns were made of a concrete much superior to that in any of the other columns made from 1:2:4 or 1:2:3½ mix, they cannot satisfactorily be compared with them. Failures of all plain columns were sudden and without any warning.

LATTICED REINFORCEMENT.—Columns B1 to B4 exhibited considerably more toughness than did the plain columns. Columns B1 and B4, outside shell removed and containing 4.5% vertical reinforcement in the form of structural steel columns, sustained an average ultimate load of 239,500 lbs. (3,740 lbs./in²). Plain concrete column F1 of the same size sustained 120,600 lbs. The steel column similar to the reinforcement in these columns failed under a load of 138,000 lbs. In tests of columns B2 and B3, the area of the outside shell was so large in proportion to the area of the core that the value of this form of reinforcement was obscured. The results of tests of these two columns, together with those of columns B1 and B4, indicate that the protective shell does not carry its share of the load in this type of column, especially when there is relatively little direct bond between it and the concrete core.

This fact was more firmly established by a retest on B2. As soon as the maximum load on this column, 303,000 lbs., was reached, the pressure was immediately released and the protective shell knocked off. The load was again applied and the column failed at 246,000 lbs. A comparison of the stresses sustained by the column before and after the shell was removed show that the shell sustained only about 40% of the average unit-stress carried by the entire cross-section. However, tests of these two columns revealed that the protective shell remained intact until the yield-point of the steel is passed. The point on the stress deformation curve at which this outside coating began to crack is indicated by a cross in Fig. 2.

The tests made demonstrate that this type of column possesses considerable toughness and a high load-carrying capacity; that the steel and concrete act together in carrying the load and in resisting deformation; and that the protective coating, although it remains intact until the yield-point of the steel is passed, should not be counted upon to resist deformations or stresses.

RODS WITH CROSS-TIES.—Columns E1 to E3 exhibited considerable stiffness. No cracks of any consequence appeared until the deformations indicated that the yield-point of the steel had been reached. At this point, however, owing to the insufficient lateral support offered by the widely separated ¼-in. ties, they failed very suddenly. The increase in strength per percent. of longitudinal reinforcement for these columns over the strength of plain columns A1 to A4 is approximately 156 lbs. per sq. in. These columns were lacking in toughness and did not have a high ultimate strength.

SPIRAL HOOPING.—The preliminary tests of the spiral columns C1 to D4 demonstrated that this type of column has great toughness and a high ultimate strength which is accompanied by large deformations and deflections. By comparing the best record [illegible] the stress-deformation curves for columns D1 to [illegible] which had vertical reinforcement, it was observed that the outside shell of concrete cracked at about the same time as the stress in the steel reached the yield-point. As may be seen in Fig. 2, the stress-deformation curves for columns C1 to C4 are practically the same up to a stress of 1,600 lbs. per sq. in. As the shell concrete in

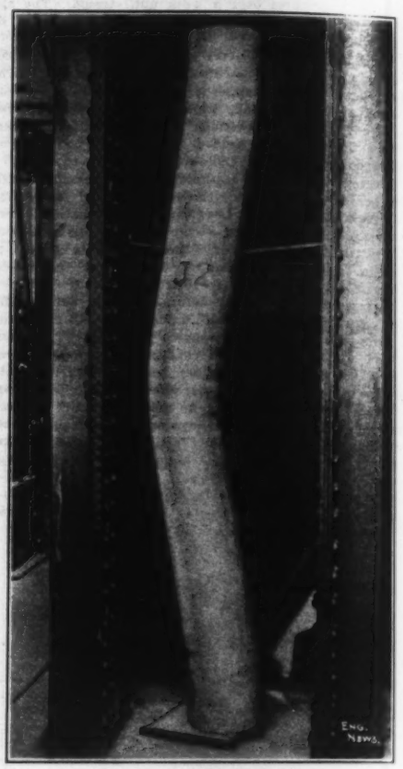


Fig. 5. View of a Reinforced-Concrete Column After Test to Failure.

(Size of column, 10½ ins. diameter by 8 ft. 6 ins. long. Longitudinal reinforcement, 8 ⅞-in. round rods = 6.11%. Hooping, spiral of No. 7 wire, 2 ins. pitch = 0.46%. Failure load 5,050 lbs. per sq. in.)

columns C1, C2 and C4 cracked at about this stress, it seems evident that the shell and core act in unison up to this point in this type of column. However, as the shell on a column in a building is liable to be greatly weakened by a fire, its strengthening and stiffening value should be neglected in such design.

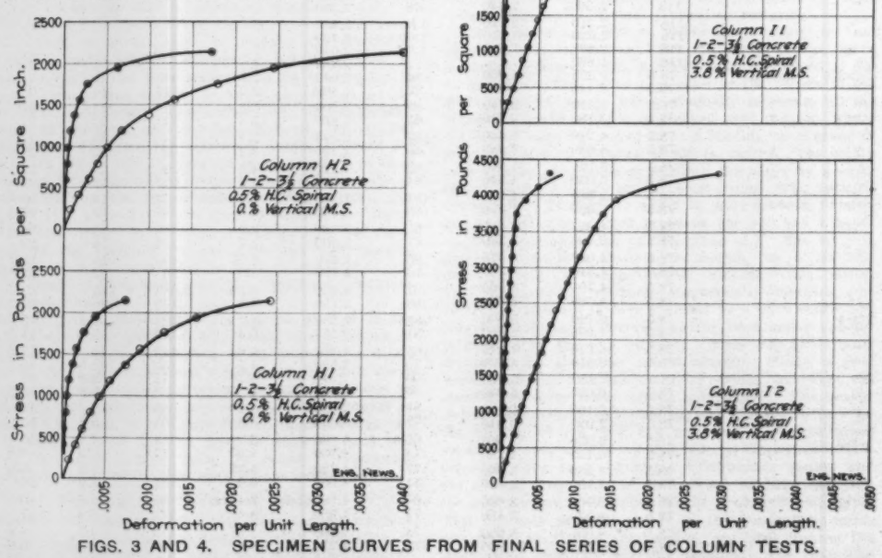
In order to more easily analyze the distribution of stress and deformation, columns H1-V2 were made with practically no outside shell. The general characteristics of columns H1-R2 under test were similar to those exhibited in the tests of C1-D4. In two instances the spirals broke after the maximum load had been passed and the deformations became excessive. Fig. 5 shows column J2 after failure; this is typical of many of the columns tested. Columns S1-V2, made from rich mixes of concrete, were considerably stiffer than the 1:2:3½ concrete columns similarly reinforced. Instead of the bulging failure found in the columns of leaner mix, a shearing failure of the concrete was plainly evident in several of these columns.

The curves for columns H1, H2, I1 and I2 (Figs. 3 and 4) showed that the yield-point is more pronounced in the columns with vertical reinforcement. The break in the longitudinal stress-deformation curve occurs at practically the same load as the break in the stress-lateral deformation curve.

Column U2, the strongest column tested, had the maximum load, 648,000 lbs. or 8,250 lbs. per sq. in., applied six times, and maintained on the column for 17 minutes on the last application before the column failed.

In computing the tabulated strengths, Table I., no allowance has been made for the strength of the thin shell outside of the spiral in computing stresses for the columns H1 to V2.

Table II. contains figures for stress in concrete and steel at the yield-point. The stress in the vertical steel was obtained by multiplying the unit longitudinal deformation by the modulus of elasticity, 30,000,000 lbs. per sq. in. The stress in the spiral was computed by multiplying the unit lateral deformation by the same quan-



FIGS. 3 AND 4. SPECIMEN CURVES FROM FINAL SERIES OF COLUMN TESTS.

tity. The stress in the concrete was found by deducting the total stress in the vertical steel from the total stress in the cross-section and dividing by the area of the concrete. The last heading of Table II. gives ratios of average strength of test-cylinders to stress in the concrete of corresponding column at yield-point.

Values of the modulus of elasticity, Poisson's ratio and the ratio n of the modulus of elasticity of steel to that of concrete (computed at one-fourth of the ultimate load and at the yield-point), are also given in Table I. The values of the modulus for columns H1-R2 have been plotted as ordinates with the corresponding percentages of vertical reinforcement as abscissas in Fig. 6. It will be noted that the values lie between the theoretical lines drawn for $n = 10$ and $n = 15$.

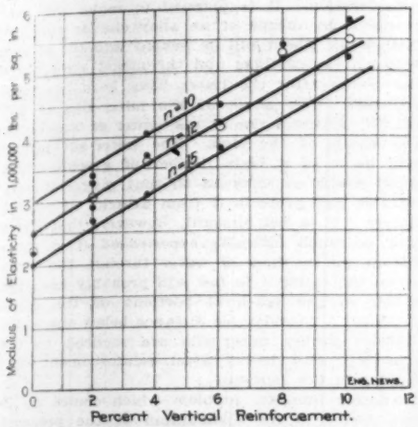


Fig. 6. Diagram of Values of Modulus of Elasticity of Reinforced-Concrete Columns for Different Amounts of Longitudinal Steel.

Table II. shows that humps in the stress-deformation curves indicate that the yield-point of the steel had been reached. The table also demonstrates that practically the full compressive strength of the concrete in the column had been developed at the same time, whereas the stresses in the spiral at the yield-point of the column were small. The ratio of the values of stress in lateral steel to stress in vertical steel is Poisson's ratio at the yield-point of the column.

In order to derive constants for formulas which would apply to the results of these tests, the columns containing the same percentage of spiral reinforcement and made of the same grade of concrete have been grouped together and the values of unit-stress at yield-point and ultimate strength plotted as ordinates with the corresponding percentages of vertical reinforcement as abscissas in Fig. 7. The general equation used for the stress at the yield-point is

$$\frac{P_1}{A} = (1 - p)\, f_c + P\, f_s \qquad (A)$$

and for the ultimate it is

$$\frac{P}{A} = (1 - p)\, f_c + p f_s + k \sqrt{p'\, f'_s} \qquad (B)$$

In these formulas

P_1 = load at yield point,
P = maximum load,
A = area of column inside of spiral.
p = percentage of longitudinal steel,
p' = percentage of lateral steel,
f_c = ultimate compressive strength of concrete,
f_s = yield-point of longitudinal steel,
f'_s = yield-point of lateral steel,
k = constant.

The equations for the columns with ½% spiral are:

$$\frac{P_1}{A} = (1 - p)\ 1{,}900 + p\ 41{,}500 \qquad (A')$$

$$\frac{P}{A} = (1 - p)\ 1{,}900 + p\ 41{,}500 + .12 \sqrt{.0046} \times 81{,}000 \qquad (B')$$

For those with 0.9% spiral:

$$\frac{P_1}{A} = (1 - p)\ 1{,}900 + p\ 38{,}700 \qquad (A'')$$

$$\frac{P}{A} = (1 - p)\ 1{,}900 + p\ 38{,}700 + .12 \sqrt{.0092} \times 96{,}000 \qquad (B'')$$

For those with 2% spiral.

$$\frac{P_1}{A} = (1 - p)\ 2{,}250 + p\ 37{,}200 \qquad (A''')$$

$$\frac{P}{A} = (1 - p)\ 2{,}250 + p\ 37{,}200 + .12 \sqrt{.0196} \times 104{,}500 \qquad (B''')$$

The values of f_s and f_c in these equations were obtained by averaging the values in Table II. for each group; the values of f'_s are given in Table I. These equations are plotted in Fig. 7.

Conclusions.

From the results of these tests the following conclusions seem evident:

(1) A small amount, ½ to 1%, of closely spaced lateral reinforcement, such as the spirals used, will greatly increase the toughness and ultimate strength of a concrete column, but does not materially affect the yield-point. More than 1% of lateral reinforcement does not appear to be necessary. The use of lateral reinforcement alone does not seem advisable.

(2) Vertical steel in combination with such a lateral reinforcement raises the yield-point and ultimate strength of the column and increases its stiffness. Columns reinforced with vertical steel only are brittle and fail suddenly when the yield-point of the steel is reached, but are considerably stronger than plain columns made from the same grade of concrete.

(3) Increasing the amount of cement in a spirally reinforced column increases the strength and stiffness of the column. A column made of rich concrete or mortar and containing small percentages of longitudinal and lateral reinforcement is without doubt fully as stiff and strong and more economical than one made from a leaner mix reinforced with considerably more steel. In these tests doubling the amount of cement increased the yield-point and ultimate strength of the columns without vertical steel about 100%, and added about 50% to the strength of those with 6.1% vertical steel. (See columns L, M, S-V.)

(4) From the behavior of the columns reinforced with spirals and vertical steel, under test and the results computed, it would seem that a static load equal to 35 to 40% of the yield-point would be a safe working load. As the ultimate strength of the concrete and the yield-point of the steel are generally known or can be assumed with fair accuracy, formula (A) can be readily used to determine the working load.

(5) The results obtained from tests of columns reinforced with structural steel indicate that such columns have considerable strength and toughness and that the steel and concrete core act in unison up to the yield-point of the former. The shell concrete will remain intact until the yield point of the steel is reached, but no allowance should be made for its strength or stiffness.

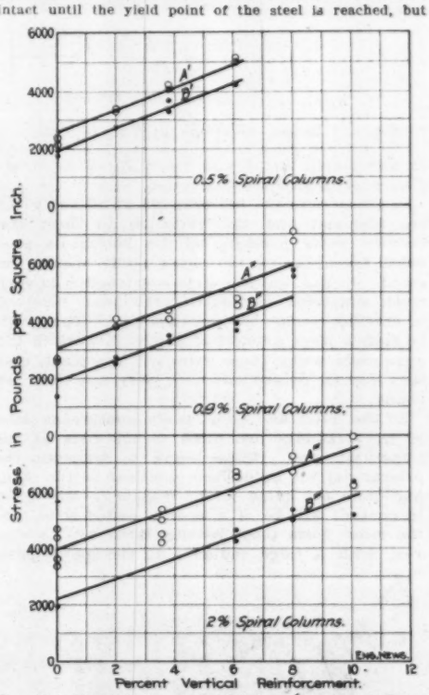


Fig. 7. Yield-Point and Ultimate Loads of Reinforced-Concrete Columns, for Different Amounts of Longitudinal Steel, and for Three Percentages of Hooping Steel.

(6) As many of the blotters on the tops and bottoms of columns bore imprints of the vertical steel after failure, it would seem a safe precaution to use bed plates as the foundations for such columns and thus prevent any possibility of the steel punching through the concrete under an excessive load.

ABSORPTION OF SULPHUR BY PLASTER.—Mr. Arthur D. Little, chemical engineer, of Boston, recently undertook to determine whether or not plaster serves to absorb sulphur gases from the air, and thus reduce the amount of sulphur below that which would naturally be expected in the room where gas is burned. The experiments were conducted in the room of an ordinary house having a content of 615 cu. ft. The ceiling upon which investigations were made consisted of exposed calcimined plaster. With extensive chemical equipment and a fan for regulating the ventilation, it was possible to determine the manner of disappearance of the sulphur gases in the room. The gas was continuously burned, and the rate of absorption by the plaster was carefully determined. When the ventilation was greatly reduced it was found that the increase in the sulphur gases was not at all in proportion to what might have been expected. To such an extent was sulphur absorbed by the plaster that in one instance only about one-third of the expected amount was found in the air. When an excess of sulphur was discharged into the air the amount dropped to less than 10% that expected.

Analysis of the plaster of the experimental room at the beginning and during the experiments showed that there had been an actual increase in the sulphur which it contained, due to the absorption of sulphur gases from the air. But it was shown that perhaps not all of the sulphur over and above that which disappears by the changing air is removed by the plaster, for a considerable portion of it may be removed with the water that condenses upon cold surfaces, particularly the walls. Mr. Little, however, calculated that the plaster of a ceiling would serve to absorb sulphur gases from ordinary gas burning 25 ft. per day during the probable existence of a house.—From the August issue of the "Chemical Engineer."

SULPHITE PITCH.—The use of common or coal-tar pitch for briquetting coal has been found undesirable in many cases because of the low temperature of ignition and its tendency to run out of the briquets, leaving the coal to fall to pieces and to clog the fuel bed. A binder which overcomes this objection and is suitable for briquetting anthracite and coke "breeze" has been found in sulphite pitch (Selpech). Consul G. E. Eager, of Barmen, Rhemish Prussia, Germany, reports on it in the U. S. Consular Reports as follows:

The material is obtained in the process of manufacturing sulphite cellulose. The wood is put through a washing process in lye by which the fiber is cleared of all resinous ingredients, it being pressed out from the wood pulp. Thus far this material has been entirely useless. Through a cooking process it is reduced to a highly glutinous substance called "sulphite pitch," which possesses a high binding power. In the ordinary briquet of bituminous coal, from 7 to 10% of coal tar is used to give the proper hardness. With sulphite pitch the same results can be obtained by the use of 5%. There are qualities of coal and ore that can easily be briquetted with from 2 to 3% of sulphite pitch.

Sulphite pitch does not soften under heat and burns at a high temperature. It can be ground to any consistency or can be produced directly in any form of powder; it can be had in every country where there are cellulose mills, and it is very cheap.

Recent trials to briquet coke gravel and dross show a briquet that can be considered a perfect substitute for coke. Practical trials of these briquets in both blast and cupola furnaces have shown that the briquets do not fall to pieces even under the highest temperature, but burn while gradually shrinking. They enter deeply into the melting zone of the furnace. Fine ore, bog iron ore, brown ore, mangan ore, oxide, furnace cadmia, iron dust from blast furnaces, and other ores can all be briquetted by the use of sulphite pitch and can be successfully melted in the furnace.

It is true that sulphite pitch can be dissolved in water, and that briquets made from it are not waterproof; the sulphite-pitch briquet is, however, more waterproof than the lignite briquet, the making of which has become a flourishing industry in Germany.

A CONSOLIDATION OF ELECTRIC LIGHT BUSINESS in and about Boston has been approved by the Massachusetts Gas & Electric Light Commission. The Edison Electric Illuminating Co. is allowed to purchase the electric plants of the Boston Consolidated Gas Co., of the Chelsea Gas Light Co., the Newton & Watertown Gas Light Co., the Waltham Gas Light Co. Also the Newton & Watertown Gas Light Co. is permitted to purchase the gas franchises and property of the Waltham company. The report of the Commission explains the action as follows:

By the terms of the several contracts executed by these companies with each other the Edison company is to pay for the electric location and property of the Boston company, $1,300,000; for those of the Chelsea company, $350,000; those of the Newton company, $500,000; those of the Waltham company, $600,000; and the Newton company is to pay $500,000 for the property of the Waltham company. The several companies also covenant that they will not further prosecute the business of furnishing electricity or gas, as the case may be, as heretofore. . . . . The direct result of the transaction will be to separate in these communities the gas business from the electric business. The facilities for furnishing and distributing light, heat and power will not in any event be diminished. . . . . Greater efficiency in operation and greater economies in costs are possible with a large lighting company serving a given territory than to several independent companies serving different sections of the same territory. There is a public advantage in having the gas and electric business separately conducted and under independent management and control. The natural rivalry between the two should result in substantial benefits to the public.

The maximum net prices for electricity in the districts of the several companies are: Edison, 12 cts.; Boston, 14 cts.; Newton, 12 cts.; Chelsea, 15 cts.; Waltham, 16 cts. per KW.-hr. Prior to the present year the price in Newton was 18 cts., but it was reduced in anticipation of the transfer of its electric property to the Edison company. The immediate results of the consolidations will be the establishment of the Edison prices throughout the territory. The Edison company has also assured the Board that after it has had time to avail itself of such economy as may follow the consolidation it will reduce the maximum price to 11 cts. throughout the territory not later than Jan. 1, 1911. With respect to the price of gas the Board has the assurance of the parties in interest that the price of gas supplied by the Newton company after the purchase of the Waltham company shall be reduced from the present price of $1 to 95 cts. on or before Jan. 1, 1910.

The Lock Gates of the Panama Canal.

In our issue of July 15, the locks of the Panama Canal were illustrated and described. In the present issue we show the most important drawings relative to the gates for the locks. These will be by far the largest and most massive lock gates ever constructed. Each pair of gates spans an opening of 110 ft. width and must be able to sustain the pressure due to a difference in head of about 80 ft. at some of the locks. There are 12 lock-chambers in all on the canal, and allowing for the intermediate gates, the guard gates and the gates placed in reverse position at the foot of the locks for use when the lock is to be laid dry there will be 42 pairs of gates required. Each of these gates is a huge steel structure about 65 ft. wide, 7 ft. thick, and of a height varying from 48 ft. to 82 ft. for gates in different locations. The structure is built up of steel plates and shapes and is designed with as much careful proportioning of parts to the stresses to be sustained as a bridge girder.

Before the adoption of the present design, a thorough study was made of the comparative merits of different types of gates. Rolling gates were studied as well as mitering gates and an especially detailed comparison was made between cylindrical and straight-backed miter gates for 100, 110 and 120 ft. widths of lock with two different angles of sill. The cylindrical gate is the most economical of material, as the two

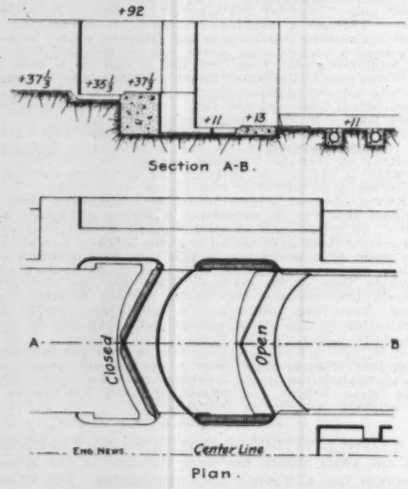


Fig. 1. Diagram Plan and Section of Part of a Panama Canal Lock Showing One Pair of Gates Closed and Another Pair Opened.

gates of cylindrical form when under water pressure form a perfect arch. The straight-backed gate, however, is much simpler and less expensive to build, and this economy more than outweighs the saving due to the arch form. An additional advantage of the straight gate over the circular gate is that the straight gate requires only a comparatively shallow recess in the masonry and does not reduce the thickness of the middle wall so much.

Structurally, each gate is built up of horizontal frames of plate-girder construction connected by a system of heavy vertical bracing and terminating at the ends in riveted steel miter posts and quoin posts. This framing is covered with sheathing plates on each side of the gate, and the sheathing is stiffened by vertical intercostals which carry the water load to the horizontal frames. It will be noted that these horizontal frames of the gate have to act both as columns and as girders when the gate is sustaining water pressure. The horizontal girders are straight on the back, or the side opposite the water pressure, and straight on the front except at the ends, where they are curved so as to reduce the thickness at the quoin and miter posts to 2 ft., the thickness of the gate at the center being 7 ft.

The vertical spacing of the horizontal girders is varied, of course, from top to bottom with the water pressure; but three standard heights of spacing have been adopted to simplify construction, viz., 3 ft. 8 ins., 4 ft. 2 ins., and 5 ft. The least of these spacings is sufficient to enable a man to enter the chamber between two adjacent horizontal girders and inspect or paint the interior. The horizontal girders are built up

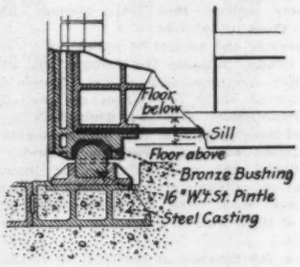


Fig. 3. Detail of Pintle at Foot of Gate Which Carries the Weight.

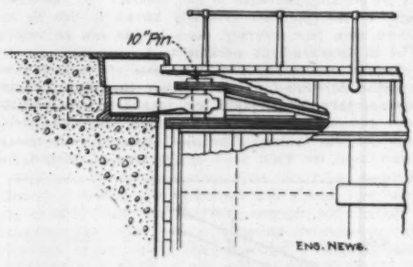
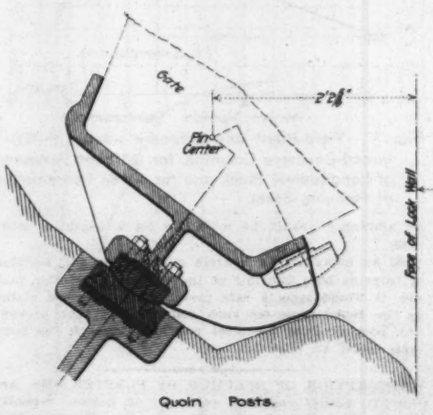


Fig 4. Detail of Hinge at Top of Gate.

of web plates, angles and cover plates, as in ordinary plate-girder construction.

In the design, the top portions of all the gates are identical and the variation to meet the heavier water pressure at the bottom is provided for by using the closer panel spacing as noted. In this way the gate construction is very much simplified, particularly the labor involved in drafting, templates and punching. There will be such a large amount of duplicate work in the huge order which these gates will represent, that they can be turned out at a very low cost per pound.

At the miter and quoin posts, continuous lines of steel castings are fitted to the ends of the structural steel. These serve to transmit the pressure of the gates from one leaf to the other and from the gates to the masonry. The faces in contact will be of a special nickel steel. At the miter posts these bearing faces will be convex, with a large radius. At the quoin posts



the contact will also be between curved surfaces. The bearing piece set in the masonry is concave, and the convex bearing face is secured to the gate leaf. The radii of these bearing pieces at the quoin have been selected so as to give a relative curvature equal to that of the convex faces of large radius used on the miter posts. The castings set in the masonry at the hollow quoin will be of steel and vary in width from the top to the bottom of the gate according to the hydrostatic head; the maximum pressure on the concrete is not allowed to exceed 450 lbs. per sq. in. under ordinary conditions.

The adjustment of the nickel steel bearing faces and the steel castings in the gate and in the hollow quoin is a problem of some magnitude with gates of such a great size and weight, as the elasticity of the gate has to be taken into consideration. It is planned to make this adjustment by means of an alloy similar to babbitt metal, which will be poured into the spaces between the castings and the nickel steel bearing pieces after the latter have been carefully adjusted. The angle of the miter-sills is 26° 33' 57", giving a rise at the center of one-fourth the width of the lock. The miter-sill proper will be a 12 × 14-in. timber of greenheart, a wood which contains an oil that makes it very durable and protects it from attacks of marine borers. It is not thought, however, that there will be much difficulty experienced from these borers, as the flow of water through the locks when the canal is in use will probably keep the water in the sea-level portions of the canal fresh for a considerable distance below the locks.

These timber miter-sills are secured to the masonry with heavy steel reinforcement embedded in the concrete.

Another intricate problem which comes up in the design is the distribution of the pressure against the hollow quoin and against the sill. The distribution of such reactions and the consequent stresses in the gate have been carefully investigated. As a result of this study, the gate and the reaction castings and the hollow quoin have been designed to withstand the full pressure coming on them even when there is no contact of the gate against the sill. On the other hand, a very unfavorable condition has been assumed as to the pressure of the gate against the sill, and the strength of the sill and of the vertical frames in the gate has been computed on this last basis.

The total weight of a single gate varies from 600,000 lbs. to 1,250,000 lbs. This load is carried on a hemispherical wrought-steel pintle 16 ins. in diameter at the foot of the quoin posts. The top of the gate ends in a 10-in.-diameter pin, anchored back by eyebars to a longitudinal and a transverse system of anchors embedded in

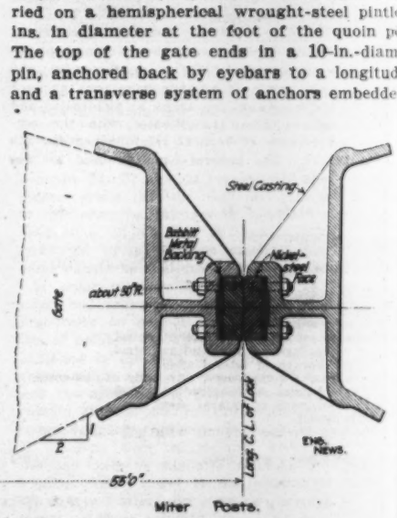


FIG. 5. DETAILS OF BEARING ON MITER POSTS AND QUOIN POSTS.

the masonry. The longitudinal anchor system is subjected to tension only, due to the pull of the gate when it is open and its weight is carried on the pintle. The transverse system withstands tension when the gate is closed, and compressions when the leaves are opened.

These anchors are carried a sufficient depth into the concrete of the lock wall to make them secure against the maximum pull of 500,000 lbs. which will be exerted when the gates are swung with the lock empty. To relieve the weight of the gate in ordinary operation, air chambers will be used in the lower part of the gate, occupying about half the height of the gate in the higher gates and reducing the working load on

the pintle and the top pin to a very moderate amount.

In the intermediate gates of the lock flights at Gatun and Miraflores, the maximum head against the gates in regular operation will be about 64 ft. When the gate leaves are closed a head equal to the full height of the gate will act on the bottom of the gate as an upward pressure and is counteracted by admitting water into the upper part of the gate to prevent the buoyant effect becoming so great as to lift the gate off the pintle. The highest gate in the Panama Canal will weigh about twice as much as the steel gates in the Royal Edward Dock at Bristol, England, with its 100-ft.-wide entrance. These gates were erected in 1908. The pressures the Panama gates will have to withstand will be fully 50% greater than those carried by the Royal Edward Dock gates. In the design of the Panama gates the engineers have aimed to follow as closely as possible designs of existing gates and to avoid complicated mechanical devices. The detail work of preparing the design of the gates has been carried out under the direction of Mr. Henry Goldmark, M. Am. Soc. C. E., Designing Engineer, to whom we are indebted for the information from which the above description has been prepared.

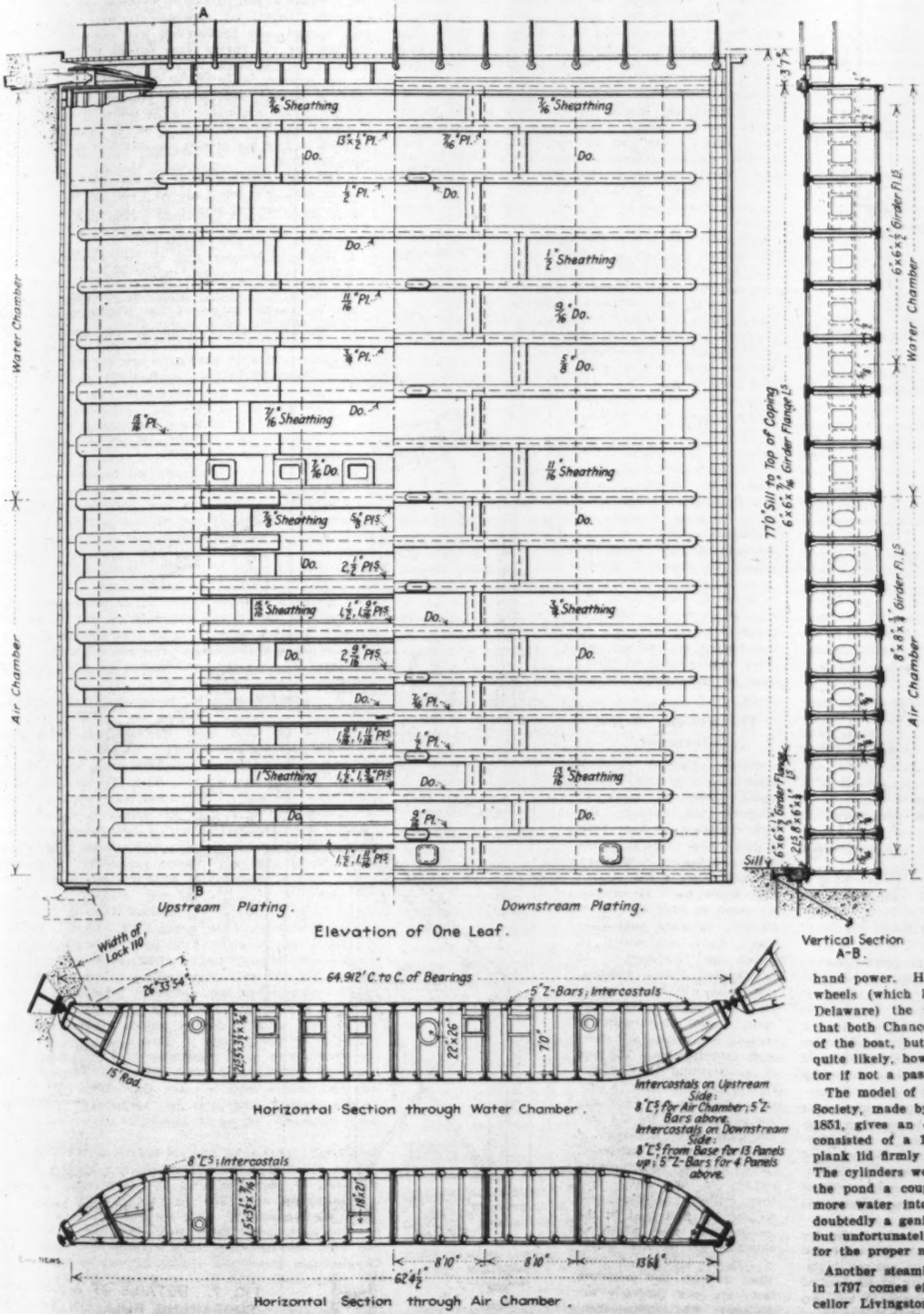


FIG. 2. ELEVATIONS AND SECTIONS OF A TYPICAL LOCK GATE FOR THE PANAMA CANAL.

Robert Fulton's Contributions to the Success of Steam Navigation.*

By EDWARD HAGAMAN HALL,† L. H. D.

During the ten years after James Watt's first experiments, inventive genius in England and France was actively engaged in developing the steam engine. Then came the interruption of the American Revolution. After the Revolution, a sort of mania for driving boats by steam began to prevail. In 1785, James Rumsey was experimenting with mechanical and steam propulsion, but it was not until 1786 that we find "the first boat successfully propelled by steam in America," according to Admiral Preble, in John Fitch's clumsy contrivance which was tried on the Delaware July 27 of that year. This boat was worked by gangs of oars or paddles arranged in a framework at the boat's sides. The priority of the experiments of Fitch and others need not deprive Robert Fulton of the distinction which is popularly accorded to him as "the father of American steamboating." But to shut our eyes to the minor successes of his predecessors is unjust to those struggling and self-sacrificing pioneers, and it is unjust to Fulton himself.

In August, 1787, Fitch ran an improved boat (the second American steamboat) on the Delaware at Philadelphia. On Dec. 3, 1787, James Rumsey ran the third steamboat, according to Preble's tables. This boat, operated at Shepardstown, on the Potomac, was propelled by means of water sucked in at the bow and expelled at the stern by the force of steam. The fourth steamboat was Fitch's, which ran from Philadelphia to Burlington in 1788. It was driven by paddles at the stern. In 1780, Fitch tried the fifth steamboat at Philadelphia. It made eight miles an hour, and in 1790 ran regularly as a packet. The sixth steamboat was a stern-wheeler, built by Samuel Morey, of Connecticut. It sailed from Hartford to New York in 1794, having on board Chancellor Robert R. Livingston and other well-known citizens of New York.

In 1796, Fitch transferred his activities to New York City. In that year he operated on the old Collect pond, which once existed where now the Criminal Courts building and city prison stand, the seventh American steamboat. In comparison with his first attempt the progress of a decade was very apparent. His first production in 1786, though a practical working boat, was a clumsy affair, but one removed from oars worked by hand power. His boat of 1796 combined with the side wheels (which had proved moderately effective on the Delaware) the screw propeller. It has been claimed that both Chancellor Livingston and Fulton were aboard of the boat, but Fulton was aboard at this time. It is quite likely, however, that the Chancellor was a spectator if not a passenger.

The model of Fitch's boat in the New York Historical Society, made by John Hutchings, of Williamsburgh, in 1851, gives an excellent idea of the craft. The boiler consisted of a 10-gal. iron kettle covered with a thick plank lid firmly fastened down by a transverse iron bar. The cylinders were of wood. After she had gone around the pond a couple of times she had to stop and take more water into her primitive boiler. Fitch was undoubtedly a genius and was working on the right track, but unfortunately could not command the means to pay for the proper machinery.

Another steamboat by Morey on the Connecticut River in 1797 comes eighth in order. In the same year Chancellor Livingston appears as more than "an interested spectator of others' experiments. The extent to which this great man went into both the theory and practice of steam navigation is realized probably by few. He is remembered for his brilliant career at the bar, on the bench, in the Continental Congress where he was a member of the Committee appointed to prepare the Declaration of Independence; in the office of Secretary for

*Extracts from a brief history of Henry Hudson and Robert Fulton, copyrighted and published by the Hudson-Fulton Celebration Commission.

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Foreign Affairs; as Minister to France and one of the negotiators of the Louisiana Purchase; but in connection with steam navigation, he is generally regarded simply as the wealthy and generous patron of Fulton. But if there had been no Fulton, Livingston himself might have been the father of the steamboat.

He had reflected profoundly on the subject of navigating the Hudson long before he first met Fulton. The extent to which he had gone into the subject is notably reflected in a letter, written Jan. 26, 1799, to President Jefferson, in which the defects of Watt's engine and the principles of steam engines are discussed. In March, 1798, he employed one Nisbet to construct a steamboat according to his ideas at a place south of Tivoli called De Koven's Bay; and this was the ninth American steamboat. This year, Fitch died, and the monopoly of steam navigation which the New York Legislature had given him in 1787 was annulled and given to Livingston for 20 years.

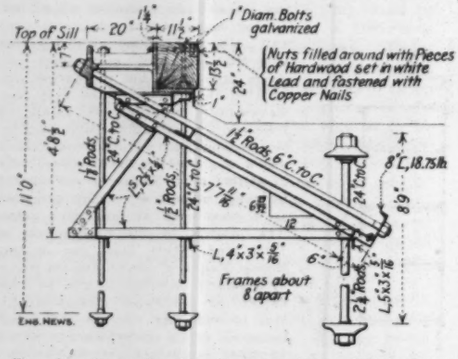
Top of Sill
1" Diam. Bolts galvanized
Nuts filled around with Pieces of Hardwood set in white Lead and fastened with Copper Nails
Frames about 8' apart
Eng. News.

Fig. 6. Cross-Section Showing Miter Sill and Its Anchorage.

The limits of this paper will not permit us to do more than mention by name five other American steamboats which appeared before the Clermont, namely (10th), Fitch's boat on the Ohio in 1798 before he died; (11th) the boat built under the joint auspices of Nicholas Roosevelt, John Stevens and Chancellor Livingston in the same year; (12th) Oliver Evans' boat on the Delaware in 1804; (13th) Stevens' boat on the Hudson in 1804; and (14th) Stevens' on the Hudson in 1806.

Fulton was born of Irish parents in Little Britain (now Fulton Township), in Lancaster County, Pa., in 1765. As a boy he manifested a decided talent for drawing, and he was frequently employed by Lancaster manufacturers to make designs for guns. He was also expert at calculation, and was occasionally engaged by gunsmiths to calculate the force, size, bore and range of guns. These two talents for drawing and calculation, thus wedded in early life, were never afterward dissociated, and to their fortunate possession were doubtless due in large measure his subsequent successes as an inventor.

At the age of 17 he left Lancaster for Philadelphia to study landscape and portrait painting and mechanical drawing. By May 6, 1786, at the age of 21 he had acquired means to buy a home for his widowed mother in Washington County.

Having thus made filial provision for his mother, and as he was suffering from pulmonary trouble, he was persuaded to go to England for his health and to study art under his former neighbor Benjamin West. But in 1793 we find him engaged on a plan for the improvement of inland navigation, and writing to Lord Stanhope, under date of September 30, 1793, concerning the principles of an invention which he said he had discovered respecting the moving of ships by steam.

In May, 1794, he secured from the British government a patent for a double-inclined plane to be used for transportation purposes. In 1795 he submitted to Lord Stanhope drawings of an apparatus for steam navigation; and in 1796 he published in London a "Treatise on the Improvement of Canal Navigation" by the use of inclined planes and the weight of water to raise vessels from one level to another.

Of the fact that Fulton possessed a decided talent for art, notwithstanding his excursions into mechanics and inventions, we have excellent proof. His portrait hanging in the rooms of the American Society of Mechanical Engineers in New York City, and ascribed to his own brush, is a highly creditable product. But the truth of Saint Matthew's saying that "no man can serve two masters" soon became apparent in Fulton's case and Invention eventually won him from Art.

During his first year in Paris he made experiments with torpedoes in the Seine. With a view to discovering a means of applying his torpedoes to the enemy's ships, his thoughts turned to submarine boats. In the spring of 1801 he went to Brest to make experiments with a plunging boat which he had constructed the previous winter. On July 3, 1801, and on subsequent dates, he gave exhibitions of his boat called the "Nautilus," in the harbor. Proceeding under sail a suitable distance from shore, accompanied by three companions, he struck the mast and sails, and plunged below the surface where, on one occasion, he remained four hours and twenty minutes. Under water, the boat was propelled by a machine worked by hand, and the respiration of the crew was maintained by a supply of compressed air in a copper globe.

In 1801 Livingston arrived in Paris as Minister Plenipotentiary. Livingston was conversant with everything that had been attempted and accomplished in America, and Fulton with everything of a similar nature in England. The coming together of these two men marks a turning point in history. With Livingston's assistance, Fulton designed and submitted to Napoleon in 1803 the plans for a side-wheel steamboat. This was constructed; but unfortunately, just as he was about to give an exhibition of its powers, it was sunk in the Seine by a heavy wind. A new boat was built, and with it, on Aug. 9, 1803, Fulton achieved a complete and brilliant success. But the former accident had produced a fatal effect. The French commission reported unfavorably and Napoleon missed one of the greatest opportunities in his career.

Discouraged by lack of Government support in France, Fulton then returned to England and made demonstrations of his inventions. He devised various methods for sinking ships with torpedoes. One of his methods was to set afloat two clockwork torpedoes connected by a rope, so that they would drift down on either side of the bow of the enemy's ship, lodge and discharge. Another device for affixing the torpedo was by means of a harpoon shot from a gun. Still another device was an anchored trigger-torpedo, to be exploded by contact.

On Oct. 15, 1805, he blew up the condemned brig "Dorothea" in Walmar Roads, near Deal, as a demonstration of the efficiency of submarine explosions. That the English officials appreciated the value of Fulton's inventions appears from their offer of a considerable reward if he would consent to suppress them forever, so that neither his own nor any other country could use them. This he indignantly refused to do.

The Voyage of the "Clermont."

Fulton returned to New York soon after this, having spent about 15 years in England and France. Before returning to New York Fulton had ordered from Watt and Bolton in England the engine for a new steamboat which, upon his arrival, he began to build at Charles Brown's shipyard near Corlear's Hook and which he called the "Clermont." In the Hudson-Fulton Celebration there will be an accurate reproduction of that historic vessel, the result of critical, painstaking and thorough investigation. The task of ascertaining the appearance of the "Clermont" a century after she was built was not an easy one, for the reason that while drawings of her engine were in existence, there was no contemporary picture of her hull. But from Fulton's statement concerning his first boat in the specifications upon which he obtained his second patent of Oct. 2, 1810,* and from other sources the following facts are now perfectly established: The original Clermont was 150 ft. long and 13 ft. wide, with 7 ft. depth of hold. She drew 2 ft. of water. Her hull (below the deck) had a wedge-shaped bow and stern, cut sharp to the angle of 60°. In horizontal plan her sides were parallel and she was almost wall-sided, being a very little wider on deck than on the bottom. Her bottom was flat with no keel and she had two lee-boards to prevent drifting sideways. She had two masts, but no bowsprit or figurehead. She had two cabins, one forward and one aft. The tiller by which she was steered was at the back end of the after cabin so that it was difficult for the helmsman to see that lay ahead. The engine, which was made in England, was amidship between the two cabins and was covered. The boiler was of copper. The paddlewheels, 8 ft. in diameter, were uncovered, which resulted in splashing the passengers, and no guards protected the wheels from collision. Later, the paddlewheels were covered. To turn around, one paddlewheel was disconnected. The flywheels of the engine were outside of the hull forward of the paddlewheels, and revolved in the same way. On one occasion, when one of the paddlewheels was disabled, it is said, paddles were attached to the flywheel and the voyage continued. In the winter of 1807 the Clermont was widened to 16 ft. on the bottom and 18 ft. on deck to give her greater stability and she was otherwise improved.

A few days before Aug. 17 of that year, this strange looking craft was taken around from the East River to the North River and moored near the old State Prison, which stood on the square now bounded by Washington, West Tenth, West and Charles Sts.

At length, on Monday, Aug. 17, the "American Citizen" contained this momentous announcement:

> Mr. Fulton's ingenious Steam Boat, invented with a View to the Navigation of The Mississippi from New Orleans upwards, Sails to-day from the North River, near The State Prison, to Albany. The Velocity of The Steam Boat is Calculated at 4 miles an hour; it is said that it will make a progress of two against The current of The Mississippi; and if so it will certainly be a very valuable acquisition to the Commerce of the Western States.

That morning the shore of the river was crowded with thousands of citizens, many of whom had come to deride what was called "Fulton's Folly." Jeers and hoots assailed Fulton's ears, and the waggishly inclined sig-

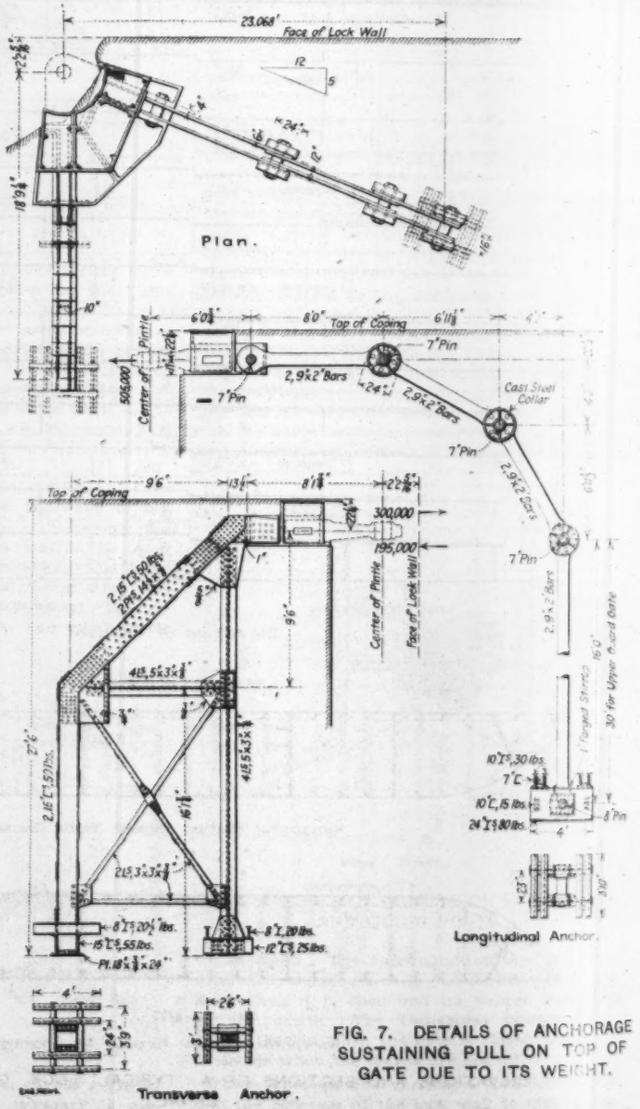

FIG. 7. DETAILS OF ANCHORAGE SUSTAINING PULL ON TOP OF GATE DUE TO ITS WEIGHT.

*Contained in "A Sketch of the Origin and Progress of Steam Navigation," by Prof. Bennet Woodcroft, of London (1848), who was a distinguished authority on patents.

nificantly tapped their foreheads. Fulton, pale, but with an air of confidence, went about his preparations to start. Presently, dense volumes of smoke began to pour forth from the smoke-stack. The boiler began to hiss. At 1 o'clock the hawser was drawn in, the throttle opened, and to the accompaniment of the stertorous exhaust, the uncovered side-wheels began slowly to revolve. A hush fell on the spectators. Fulton's own hand at the helm turned the bow. The "Clermont" moved out into the stream, the steam connections hissing at the joints, the crude machinery thumping and groaning, the wheels splashing and the smoke-stack belching like a volcano. The boat continued to gather momentum and move away. Then the nervous tension of the situation was broken. All on board swung their hats in the air and gave a cheer, and like an echo, magnified a thousand times, came back a roar of applause from the shore. The skeptics had been converted.

As the steamboat proceeded up the river, it spread consternation among superstitious mariners and unsophisticated countrymen. No such sight had ever been seen before. The pine wood used for fuel produced a torrent of black smoke, flame and sparks, which belched forth to a great height above the smoke-stack. The reverberation of the exhaust as the boat passed the Palisades was something absolutely unheard before by human ears in this region. Crews of other vessels were terrified. Many at first sight fell on their knees, disappeared below decks or made for land. One honest countryman, after beholding the unaccountable object from the shore, ran home and told his wife that he had seen "the Devil on his way to Albany in a saw mill." Not since Hudson's "Half Moon" had sailed over the same course nearly 200 years before, exciting the wonder and awe of the aborigines, had such an amazing sight been seen by the neighboring inhabitants.

At 1 a. m. on Tuesday, the boat arrived at the place after which Fulton, in honor of his distinguished colleague, had named the steamboat. Clermont dock, the landing place at Chancellor Livingston's place, is 110 miles from New York, and that distance had been traversed against the wind in just 24 hours. The average speed thus far had been about 4.6 miles an hour. Here Fulton rested until 9 a. m., Wednesday. The "Clermont" reached Albany, distant 40 miles, at 5 p. m. on this day. The running time for the whole 150 miles had been 32 hours, or at the rate of nearly 5 miles an hour. The return trip on Thursday and Friday was made in 30 hours running time, or an average of just 5 miles an hour. The wind had been against the "Clermont" both ways, says Fulton, so that no advantage could be derived from his sails. The whole journey, therefore, had been performed by the power of the steam engine.

Fulton's victory was won by a narrow margin, for competition was following close upon his heels, and could John Stevens, of Hoboken, and his son, Robert L. Stevens, have obtained engines in time, they might have anticipated the "Clermont." As it was, Stevens' "Phoenix" sailed upon the Hudson only a few days later than the "Clermont," in 1807, but as a result of the monopoly which Livingston and Fulton secured from the Legislature in 1808, Stevens was crowded out, and in June, 1809, he took the "Phoenix" around Cape May to the Delaware upon which she plied many years between Philadelphia and Trenton. She is claimed to have been the first ocean-going steamboat.

In 1808, Fulton built the "Car of Neptune," and in 1812 the "Paragon," the third of the Fulton-Livingston line of Hudson River boats. The "Paragon" was a great improvement on her predecessors. She was 173 ft. long with 27 ft. breadth of beam. She had a copper boiler 21 ft. in length, fitted with numerous pipes to facilitate the generation of steam, something after the modern tubular system, but owing to some injury to the pipes from fire on the first experiment they were abandoned. The "Paragon" ran many years between New York and Albany; but about 1820 she ran upon a rock and was abandoned. The round trip from New York to Albany and return on the "Paragon" as on the "Clermont" cost $14.

In 1812, Fulton started his first ferry-boat. The enterprising Stevens had started a ferry to Hoboken in October the year before, but eventually had to give way to Fulton. Of Fulton's boat which ran from Cortlandt St. to Jersey City, Fulton said: "It crosses the river, which is a mile and a half broad, when it is calm, in 15 minutes; the average time is 20 minutes. She has had in her at one time eight four-wheel carriages, 29 horses and 100 passengers, and could have taken 300 persons more."

This boat was built on the catamaran principle, consisting of two boats, each of 10-ft. beam and 80 ft. long, separated from each other by an interval of 10 ft. and covered with a deck 30 ft. wide and 80 ft. long. The paddle-wheel was in the space between the boats, protected from ice and collision. She was symmetrical at both ends, and, having a balanced rudder at each, was not obliged to put about on the return trip. Thus we see that our end-wise system of receiving and discharging ferry passengers dates from the very beginning of steam ferriage. Fulton also devised the ferry bridge as used essentially to-day. It was attached to the wharf by a horizontal hinge, the outer end resting on a float which rose and fell with the tide. He provided, in addition, an ingenious bumper with hydraulic counterweights to receive the impact of the arriving boat, which in later years proved to be unnecessary.

The outbreak of the War of 1812 with Great Britain naturally turned Fulton's thoughts again to his purpose to rid the seas of British oppression. In March, 1814, Congress authorized the construction of the first steam vessel of war according to plans submitted to Fulton, and this vessel, called the "Demologos," or "Fulton the First," was launched, but not completed, Oct. 29, 1814. She was built, like his ferry-boat, on the catamaran principle, and consisted of two hulls, 66 ft. long, separated by a channel 15 ft. wide. The paddle-wheel was within this central channel. She had a parapet 4 ft. 10 ins. thick; portholes for 30 32-lb. guns; two bowsprits and jibs; two masts; and four rudders, one at each end of each hull.

The launching of this vessel was a great event in New York. Multitudes crowded the shores, and the river and bay were filled with vessels of war dressed in all their colors. In their midst was the enormous floating mass, saluted by land batteries, bands of music and the cheers of the people. The enemy had endeavored to prevent the building of the frigate by blockading the port and cutting off necessary supplies, but he only succeeded in increasing the expense. The vessel was completed; equipped with guns opportunely captured from the British and transported over miry roads from Philadelphia to New York; and on July 4, 1815, she made a trip to sea and back, a distance of 53 miles, in 8 hours and 20 minutes. But on Feb. 17, the treaty of peace with Great Britain was ratified at Washington and the war was over.

Fulton, while present at the launching of the "Demologos," did not live to see her completed, but died Thursday, Feb. 23, 1815, at his home which stood in what is now Battery Place, New York City, in the rear of No. 1 Broadway.* In January, he had caught a severe cold while at Trenton attending a hearing before the New Jersey Legislature involving the right of John R. Livingston to run a ferry-boat between New York and New Jersey. Returning from Trenton, he found the river full of ice, and he was detained on the water several hours on a very severe day. Notwithstanding the cold he had caught, he was so intensely interested in the completion of the frigate that he disregarded the proper precautions for his health. He spent many hours in inclement weather on the decks of the "Demologos," supervising the work, and at last succumbed, the victim of his devotion to his great work.

If we could assemble in New York Harbor a fleet embracing all the steam vessels constructed by Fulton or according to his plans, we should have an impressive exhibit of his productive powers. First we would see the little diving "Nautilus" (1801). Then would come the little boat on the Seine (1803), and then the "Clermont" (1807), "Car of Neptune" (1808), "Rariton" (1809), "New Orleans" (1811), "Paragon" (1812), "Firefly" (1812), "Jersey," ferryboat (1812), "Camden" (1812), "Washington" (1813), "York," ferryboat (1813), "Richmond" (1814), "Nassau," ferryboat (1814), "Fulton" (1814), "Vesuvius" (1814), "Demologos" (1814), "Aetna" (1815), "Buffalo" (1815), "Mute" (1815), "Olive Branch" (1816), "Empress of Russia" (1816), and "Chancellor Livingston" (1816).

But even this exhibit would represent only a part of Fulton's genius, which expressed itself in his valuable pioneer work with submarine boats, torpedoes, inland canals, and in other directions for the promotion of the peace and prosperity of mankind.

A GRAND PARKWAY for Philadelphia, extending from the City Hall to Fairmount Park, has been under construction for some time past, and some work, we believe, has already been done upon it. Final decision as to widths and property takings is about to be made. It is stated that the latest plans include a parkway or boulevard 140 ft. in width for that portion east of Logan Square, and 250 ft. in width west of that square. The land taking will afford sites for plazas, public and semi-public buildings. The approximate assessed valuation of the property to be acquired for the parkway is $9,000,000. It is, of course, expected that the actual amounts paid will far exceed this sum. It is stated that $2,000,000 has already been spent upon the parkway, and that construction costs will approach $1,000,000.

THE ROYAL COMMISSION ON SEWAGE DISPOSAL, appointed by Queen Victoria in 1898, had expended nearly $280,000 in its investigations up to August, 1909, according to a reply to a parliamentary question, made by Mr. John Burns, President of the Local Government Board. In the same reply Mr. Burns stated that the final report of the Commission was not to be expected for some 18 months to come.

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*The date and place of Fulton's death above given though differing from those given by his biographers Colden and Reigart are authentic, being based upon obituary notices in contemporary newspapers and upon the city directory of that year.

The Annual Convention of the New England Water Works Association.

The New England Water Works Association is by no means as local as its name implies. It has a membership scattered throughout the country and does not always hold its meetings within the New England territory. On Sept. 8-10 it held its annual convention in New York for the second time. The attendance was fair and the time of the convention was well divided between presentation and discussion of papers, excursions and general sociability. Four or five papers and several committee reports were presented at the business sessions. The excursion feature of the convention was a trip to the Ashokan Dam, on Friday, Sept. 10, where the party was entertained by the engineers engaged on the development of the new Catskill water supply for New York City.

At the opening session on Sept. 8, after an address of welcome by Mr. George S. Rice, Chairman of the Committee of Arrangements, and other preliminary business, the convention opened with an address on the New York water-supply by Mr. William W. Brush, Engineer of Distribution of the Water-Works of New York City. The address, which was illustrated by many lantern slides, outlined the water-supply system of Greater New York and filled in as much detail as was possible in an hour and a half.

Odors and Tastes in the Water-Supply of Holyoke.

This paper was presented by Mr. James L. Tighe, City Engineer of Holyoke. The author reviewed the experiences of Holyoke with tastes and odors in stored surface water, from the early '70's to date. Some curious and interesting extracts from early reports and newspaper articles dealing with the taste and odor nuisances were presented. Among the various suggestions for alleviation made at one period were windmills and a flotilla of boats for agitating the water and thus aerating it. Another suggestion was that large ice-houses be built on the shores of the reservoir chiefly at fault, and the water surface kept exposed by cutting and removing the ice—the organisms giving rise to tastes and odors being particularly persistent in winter.

Coming down to the application of modern scientific methods for the study of the causes of tastes and odors in public water-supplies, Mr. Tighe outlined the system of microscopical examinations of water taken from selected points at fixed intervals, introduced some years ago. The chief organism that gave trouble during the first year after microscopical examinations were introduced was uroglena. Later on, trouble was experienced with sinura. Still later, but in connection with another source of supply, anabaena made a disturbance. The appearance of anabaena followed a change in handling the sources of supply, by which, in order to increase the pressure, water from one of the reservoirs was introduced directly to the supply main instead of flowing some 1,600 ft. through a sloping channel which led to a small intake reservoir. It appeared that the aeration afforded by this channel was sufficient to obviate trouble from anabaena.

No organic matter had been removed in the construction of the earlier reservoirs, although after construction some of the shallower areas had been cut off by dikes. In a reservoir completed in 1904 and filled for the first time in 1906, some $50,000 to $75,000 was spent in stripping organic matter from the reservoir bottom. Notwithstanding this, bad odors and tastes developed. The organisms causing these were not found within 12 ft. from the surface; some were found at the bottom, but most of those shown by the examinations were in samples collected between 12 and 20 ft. from the surface. Dilution of the water in this reservoir by water from another source seemed to stop the trouble.

In another reservoir there has developed of late a luxuriant growth of a large aquatic plant known as chara. This growth occurs on

the sides and bottom of the reservoir down to a depth of 20 ft. and is at its maximum at 13½ ft. from the surface. It flourishes best on rock and clean gravel. As an experiment to test the effect of frost or of low temperatures, this reservoir was kept empty during 1908-09. No trouble was experienced during the summer of 1909.

Questions asked Mr. Tighe by various members brought out the statement that no copper sulphate has ever been used to prevent growths in the Holyoke reservoirs, nor anywhere in a waterworks reservoir in actual service in the whole state of Massachusetts. The agent has not been favored by the State Board of Health.

Water Purification at Poughkeepsie, N. Y

A historical and descriptive account of the water-works at Poughkeepsie, N. Y., with particular reference to filtration and subsequent sedimentation, coagulation and disinfection, was presented on Thursday morning by Dr. John C. Otis, President of the Board of Public Works of Poughkeepsie. As many of our readers know, Poughkeepsie was the first city in the United States to install a slow-sand filtration system along English lines. After doing service for many years as a small open filter, the Poughkeepsie filter was extended in area and a masonry covering provided. The plant as finally enlarged was put in operation in 1905, and consisted of four units of ⅛-acre area each. At the very close of 1907 a sedimentation basin was put in operation. During 1908 sulphate of alumina was used as a coagulant in connection with this basin when the turbidity of the river water demanded it. It having been found during the winter of 1908-09 that the combination of coagulation, sedimentation and slow-sand filtration did not always reduce the bacteria to the extent desired, a small and inexpensive plant was installed, and by means of it chloride of lime or bleaching-powder, was added to the water in the sedimentation basin. Tests showed that about 0.4-part of available chlorine per 1,000,000 gals. of water was sufficient. By its aid, in conjunction with coagulation and sedimentation, a very high percentage of bacterial removal is effected, sometimes reaching 99%. The cost of the chlorine treatment, including the whole capital charges, is only about 15 cts. per 1,000,000 gals.

WATER-WORKS FINANCES OF POUGHKEEPSIE.—Interesting financial data presented by Dr. Otis showed in brief that over a long period of years the average cost of supplying water to Poughkeepsie, including interest charges, was about 9 cts. per 1,000,000 gals., as compared with the average receipts of 4½ cts. Only a very small percentage of the bonds issued for the construction of works during the first 37 years of their existence were paid off, but some of the bonds were refunded meanwhile at a rate of interest considerably lower than the original 7%. It would appear from what Dr. Otis stated that had a reasonable proportion of the bonds been retired, the net loss on operating the works would have been materially increased; although, of course, this increase would have been partly set off by the reduction in interest charges that would have been effected by retiring the bonds. It should not be understood that the loss on the municipal ownership and operation of the Poughkeepsie water-works was at the rate of 4½ cts. per 1,000,000 gals., for during the whole of the period indicated the works received no credit for water supplied for fire protection or other municipal uses.

It is the purpose of those now in authority at Poughkeepsie to readjust the rates on such a basis as to make the works self-supporting—a problem which, as we understand it, will be simplified by the fact that all or nearly all the water-supply is metered.

After concluding the reading of his paper and showing some lantern slides, Dr. Otis raised the question, as a layman, whether it might not be possible to so treat water by chemicals and sedimentation, or at least by mechanical filtration, that slow-sand filtration would be unnecessary. In answer to this query, Prof. E. A. Phelps stated that, although he had great faith in the disinfection of water-supplies, yet disinfection should not be considered as a substitute for filtration, as there remains other work than mere bacterial removal for filters to do. Prof. Phelps also remarked that in considering disinfectants ozone should not be lost sight of. Ozone has a "black eye" just now, he remarked, but he considered that the ozone treatment had broken down only temporarily, owing to mechanical difficulties and to its cost. He thought it reasonable to expect that a method of producing ozone would yet be perfected which would be sufficiently inexpensive to warrant the use of that valuable agent for treating water.

At the final session on Thursday evening a paper entitled

Disinfection as an Adjunct to Water Purification,

by H. W. Clark, Chemist, Massachusetts State Board of Health, Boston, Mass., and Stephen De M. Gage, Biologist, Massachusetts State Board of Health, Lawrence, Mass., was presented by the latter. This paper dealt with an extensive series of experiments conducted at Lawrence. The experiments as a whole have been dealing with disinfection of sewage as well as water, and have embraced practically every disinfecting agent available. The paper on Thursday night, however, related almost wholly to the use of bleaching-powder. The paper was an interesting and excellent supplement to that portion of Dr. Otis's paper on the Poughkeepsie water-works which dealt with the use of bleaching-powder there. An abstract of the paper by Messrs. Clark and Gage is given elsewhere in this issue.

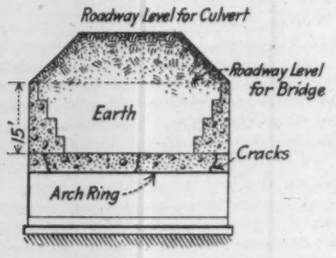

Fig. 1.

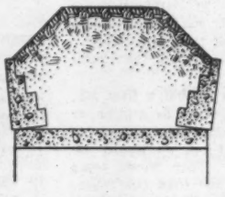
Fig. 2.

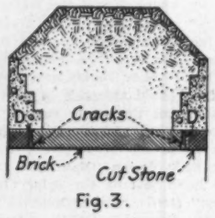

Fig. 3.

Papers on water-works accounting, by Mr. Harvey S. Chase, of Boston, and on the water-works of Camaguey, Cuba, by Mr. Henry A. Young, of Yonkers, were not read, on account of the fact that the authors were not present. Mr. Chase's paper will be presented at one of the winter meetings of the association. The paper by Mr. Young will appear in the Journal of the Association without being read.

Brief reports of the conservation committee and of the committee on damages resulting from the diversion of water were made by Messrs. M. N. Baker and Leonard Metcalf, respectively. Mr. Metcalf stated that his committee had been so fortunate as to secure reports on about a hundred water award cases and expected a number more. These reports will be abstracted and the figures given will be tabulated for presentation to the association in the future. It is expected that advance copies of these extensive data will be distributed to members, and that a brief abstract only will be read before the association, thus affording full and free opportunity for discussion.

Common Errors in the Design of [C]ulverts and Earth-Filled Arch Bridg[es]

By W. J. DOUGLAS,* M. Am. Soc. [C.E.]

There is one force, in the design of cu[l]verts and earth-filled bridges, which is not giv[en] proper consideration. This is the horizontal fo[rce] of the earth which must be properly transmit[ted] to the arch ring. In culvert and bridge desi[gn] where the retaining walls are between 5 and [20] ft. in height, the lack of consideration of this h[ori]zontal force results frequently in the formati[on] of unsightly cracks on the arch and occasi[on]ally in the failure of the retaining walls. For [in]stance, in the sketch herewith (Fig. 1), the h[ori]zontal thrust is something over 3,000 lbs. per f[oot] of ring without taking the surcharge into consi[der]ation. Now, with a ring having a depth at the c[row]n of 24 ins., this amounts (in tension) to appro[xi]mately 11 lbs. per sq. in., decreasing as the ring i[n]creases in thickness. With any ordinary methods of bonding there is no reason why the arch should be pulled apart due to this horizontal thrust; however, this horizontal force, when combined with very slight settlements of foundations, often results in cracks in the barrel of the arch, as shown. It also results in unequal pressure upon the arch ring at the toe of the retaining wall. Attention should be called to these cracks in order to indicate the necessity of bonding the work for this thrust as well as for direct arch pressure.

The more common method of failure, however, in small culverts is the sliding forward (and eventual rotation) of the retaining wall along the bed XX (Fig. 2), where no bond is provided between the extrados of the arch and the retaining wall. Of course a wall with a base one-third to one-half of the height would not slide unless the surcharge was very heavy.

The third case of failure is where the arch ring is of brick faced with cut stone. (This may also be true when a concrete barrel is faced with ashlar, but such an effect has never come under the observation of the writer.) The writer has seen at least a dozen culverts in which the arch ring was built of brick faced with stone, as in Fig. 3, where a crack had formed at the junction of the stone facing and brick ring as at D. The stone arch ring compressing somewhat less than the brick results in the former carrying a larger percentage of the thrust of the retaining wall and, eventually, possibly this entire thrust is carried by the stone ring and the stone facing separates from the brick. In a skew culvert or bridge this crack would be even more likely to form than in a straight culvert or bridge. The writer has a case in his own design, built about seven years ago, at one end of which long face stones, alternating 4 ft. 6 ins. and 3 ft. 6 ins., were used, and at the other end, funds being a little low, the length of these stones, measuring along the barrel of the arch, were reduced to 3 ft. and 2 ft., respectively. Many of the longer stones (4 ft. 6 ins. and 3 ft. 6 ins.) separated from the barrel to the extent of 1-16 to ⅛-in., whereas the shorter stones at the other end remained in position. It appears from this particular case that the shorter the face stones, if they are to be used at all, the better chance there is of them remaining in position. This is based on sound theory, because the shorter stones would carry a smaller portion of the concentrated pressure. A rough calculation would indicate in a great many cases that in concrete retaining-wall bridges and concrete culverts, transverse rods (perpendicular to the face) should be used to take care of this horizontal thrust, and where it is desirable to have a stone facing each stone should be carefully fastened to the barrel of the arch. This is an old custom which has gone out of fashion during the last 20 years. Of course the bottom of the retaining wall should be well bonded to the extrados of the arch also.

THE TAXICAB IN LONDON is reported by Vice-Consul General Richard Westacott to be rapidly supplanting the horse-drawn vehicle. The number of licensed hansom cabs on July 1 was 4,039, a decrease of 1,290 in one year; four-wheeled cabs, 3,379, a decrease of 389; motor cabs, 3,304, an increase of 1,886. It will thus be seen that in one year the number of taxicabs has more than doubled.

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ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
ATLANTA: Candler Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
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Entered at the New York Post-Office as Second-Class Matter.

The most interesting and promising recent advance in water purification is the use of bleaching-powder, or chloride of lime, as a disinfectant. At the meeting of the New England Water Works Association held in New York last week, two papers dealt with this new agent. One told of its application in every-day use at the waterworks of Poughkeepsie, N. Y., and the other reviewed some extensive experiments with bleaching-powder and other disinfectants at the Lawrence Experiment Station of the Massachusetts State Board of Health. Practice and theory at Poughkeepsie and Lawrence confirmed each other.*

The changes of time could scarcely be better illustrated than by the story of water purification at Poughkeepsie. The first slow-sand filter plant in the United States was built by that city about 1870. After a checkered career of many years, the Poughkeepsie filters were improved, extended and covered. Then a sedimentation basin was installed for preliminary treatment of the water, and a coagulant employed. Quite recently a disinfecting solution, as well as a coagulant, has been applied to the water, so that now the improved slow-sand filters at Poughkeepsie are receiving water which has had the triple benefit of sedimentation, coagulation and disinfection.

Particular attention may be called to the fact that disinfection as practised at Poughkeepsie, and as experimented with at Lawrence, is not used as a finishing process, as one might expect, but rather as a preliminary to filtration. It should be understood that the results with the disinfectant at both Poughkeepsie and Lawrence are to be considered as applying to bacterial reduction. For removing turbidity, reliance is of course placed upon coagulation and sedimentation, and at other places where the turbidity is higher, filtration might also be imperative.

Finally, we wish to call attention to the fact that in both water and sewage purification the tendency of the day is strongly towards lessening the burden upon filters of whatever sort by the removal or reduction of the suspended matters by one means or another with preliminary treatment.

*See also Engineering News, June 24, 1909, pp. 693, 697. Disinfection of Water at Boonton, N. J.

Grade-crossing accidents are of such common occurrence that they seem to arouse no particular interest except in those cases where a number of persons are killed or very seriously injured. Several cases of this sort have come to our attention during the past month, and the continual frequency of such accidents is evidenced by the statistics of the Pennsylvania Railway Commission which show that, during the first six months of the present year, 26 persons were killed and 109 injured at grade crossings in that state alone.

Everyone has become accustomed to the ordinary type of grade-crossing accident, involving a horse-drawn vehicle or a street car. Examples of this type are furnished from the records of the past month in the accident at Kennett, Mo., Aug. 15, when a wagon was struck by a train and five persons killed, and the accident at South Chicago, Ill., Aug. 5, when a railway train demolished a street car, killing the conductor and injuring 50 passengers.

Of late years, a new type of grade-crossing accident has come into prominence and appears to attract attention more because of its novelty and the social status of its victims than for any other reason.

The automobile is a particularly apt participant in accidents of this sort. It approaches grade crossings at a speed that prevents a preliminary lookout for trains where an extended view of the tracks is not possible until close to them, and this very ability for high speed seems to inspire the automobile driver with more than the usual human recklessness. Two very similar accidents in which automobiles were struck by trains were reported recently, one Aug. 29 at Vigus, Mo., where five persons were killed and the second Sept. 2 at Douglassville, Pa., with four victims. Testimony before the coroner for the Vigus accident showed that the locomotive whistle had been sounded a few seconds before the collision and that the bell was ringing when the crash took place. At Douglassville an electric signal gong was announcing the approach of the train. These warnings passed unheeded in both cases, due possibly to their obliteration by the noise of the automobiles.

In the cases mentioned, not only were the crossings quite unguarded but obstructions of one sort or another prevented an extended view of the track to anyone approaching the crossings along the highway. After the accidents, efforts were made, by removing such obstructions or by placing warning signs at some distance back from the crossing, to prevent their recurrence. While such efforts are certainly to be commended, it would be wiser for the people, and especially the automobile clubs, of localities not yet afflicted to profit by the experience of others instead of waiting until the dangerous crossings in their neighborhood are marked out by disasters.

Until quite recently it has been almost universally true that people going from the city to the country for their health virtually took their lives in their hands meanwhile. This has been due to the utter lack of observance of the most elementary principles of sanitation which has generally prevailed in summer resorts, as well as at the isolated farm-houses and other boarding-houses throughout the country. A few of the more progressive states have been giving attention to the improvement of the sanitary conditions of summer resorts, but as yet very little has been done for the protection of city people who go to isolated houses in the country.

Since the New York State Department of Health took on new life a few years ago, it has been making as extensive investigations of summer resorts as its limited funds would permit. In the July bulletin of the department the results of inspections of 1907 and 1908 are summarized. On the face of the returns the results found in 1907 were in many instances deplorable, and the inspection in 1908 showed that the required improvements had by no means been made in all cases, although many improvements were recorded. As an illustration of the results of these inspections it may be noted that of 64 premises in the Catskills inspected in 1907, the water-supply, plumbing or sewage-disposal systems were found defective in 19 instances. The re-inspection of 1908 showed that the unsanitary conditions reported had been corrected in 12 of the 19 cases and partially corrected in 4 others. The improvements noted were a greater percentage of the total premises inspected in the Catskills than in some of the other resort regions. The bulletin gives no information as to the relative degrees of nuisance or defects which were found to exist. Some of them, very likely, were not serious menaces to health, but their existence, and the failure to remedy defects found on reinspection in a number of cases, show the ignorance and indifference which has hitherto prevailed at a large percentage of the summer resorts in New York State. We have no reason to believe that as a rule conditions are better in many of the other states of the Union.

It seems a great pity to think that hundreds of thousands of people should leave our cities every year in search of recreation and health, only to expose themselves to far greater dangers from certain communicable diseases than they experience when in their homes. It would be a prudent thing for every head of a family to make an investigation, through some effective means, of the conditions, at mountain or seashore, to which his family is to be subjected during its summer outing. Numerous applications for such information, addressed to State and local boards of health, would give a marked stimulus to sanitary supervision; letters to proprietors or summer hotels and boarding-houses, followed by personal inspections by prospective boarders, would perhaps have a still more salutary effect.

Although the convention of the New England Water Works Association held in New York City last week devoted considerably more time to the presentation and discussion of papers than did the recent convention of the American Society of Civil Engineers held at Bretton Woods in July, yet somewhat the same criticism has been heard regarding each convention; namely, that the work in the formal session was neglected on account of social and other diversions. In the case of the meeting of the New England Water Works Association, unfavorable contrasts were drawn with the recent convention of the American Water Works Association at Milwaukee, where a large number of papers were presented.

It is difficult to strike a happy mean in arranging a convention program. In theory, a considerable number of those who attend conventions wish to hear instructive papers and perhaps take part in discussions; in practice, the percentage of those registered who attend the business sessions indicates that other attractions are often more powerful.

In comparing conventions of various associations, it should be remembered that there are some essential differences between organizations whose activities are confined to an annual convention, and societies which have frequent stated meetings throughout the year and issue a journal or other publication every month or quarter. What may be termed the yearly societies are compelled to justify their existence by what can be crowded into their annual meetings and single volume of proceedings. Inasmuch as a small percentage of the total membership of any national organization can attend a convention, all that a large majority of the members get for their membership fee is the annual volume of proceedings. This being the case, it seems necessary to have a lengthy program of papers and discussions. With the other class of societies, the annual meeting may quite properly give a large proportion of its time to social features and excursions.

One of the chief benefits derived from membership in any society or attendance at any convention arises from the opportunity to meet

others engaged in similar work, to form and renew friendships and discuss together matters of mutual interest. Men in responsible positions have opportunity of meeting and "sizing up" the younger men for whose help they may sometime call when a position is to be filled. Business and professional competitors have an opportunity to meet on common ground and gain the great advantage of personal acquaintance. At any convention the discussion of professional or trade or technical matters which is carried on by knots of two or three is often more useful and more important to many of those who attend than the formal discussions in the convention hall.

On the other hand it must be remembered that in every society there are many members who are attracted to the conventions by the program of papers and discussions and who measure the value of the society to them by this alone. To provide for these and for the stay-at-homes, the papers and discussions at a convention ought always to be the best that the energy and ability of the managing officers and the means at their disposal can secure.

Live-Loads and the Life of Railway Bridges. For What Loading Should Railway Bridges Be Designed?

Railway bridges have always occupied a peculiar position among engineering structures on account of the steady increase in engine and train weights. Bridges could not remain "modern" very long, but were outgrown after a very short period. It was always the custom to design for existing loadings, or at most only a small margin of increase. But loads continued to increase and to render new bridges obsolete.

The same custom still prevails. There is to-day better reason for expecting that train loadings will remain practically stationary. Freight cars have reached a very high capacity, and engines, while still increasing in weight, show little or no increase in wheel-loads but distribute the additional weight over added length of base. May we, therefore, expect that the bridges which are now being built will have a longer term of life than those of the past generation?

Just now many railway bridges built in the 80's are being taken out and replaced by heavier structures. An example of such renewal, interesting for a variety of reasons, was described in our last issue (Ohio River bridge at Point Pleasant, on the Kanawha & Michigan Ry.). This bridge lived to be 25 years old. A parallel instance from a larger and more prominent railway is the case of the Panhandle bridge over the Ohio at Steubenville, O. This is only 20 years old, but it has also become too light and is therefore being replaced.

These bridges, as well as many others which are being removed, have not rusted out, but on the contrary are usually in excellent condition as regards corrosion. On the score of rusting alone they would be only just entering the prime of life. But the weight of trains outgrowing their strength, they show the very short life of twenty-five years at most.

Doubtless the bridge designers of twenty years ago did not anticipate this; they did not believe that their bridges would be outgrown in barely two decades. They were at that time taking down the bridges of the preceding generation, "antiquated" bridges, and had before them good models of what to avoid in the way of short-lived construction. They knew how rapidly engines and trains had become heavier, and probably believed there would be little further increase. Yet hardly a dozen years had passed before their estimated loadings were surpassed by the actual rolling-stock, and soon thereafter the matter of renewal became a question only of favorable opportunity.

Doubtless also the designers of to-day are loth to believe that their work is to live only twenty years. With thoroughly modern design in all details, and with engine and train weights apparently near their physical limits, there is no obvious ground for fearing that, with good protection against rust, our new bridges of to-day may not be fully satisfactory after twenty to twenty-five years. It is quite clear that this view must be held rather generally, since the loadings on which new designs are based contain but small allowance, if any, for future load-increase. Otherwise, it would be a simple and comparatively cheap matter to provide for a considerable increase in live-load, certainly much cheaper than the complicated and bothersome rebuilding under maintained traffic, of which kind of work we have a fair sample in the account of the Point Pleasant bridge.

It is a fact that there is no immediate prospect of greatly increased loadings. The 50-ton car is not likely to be far outstripped even for the heaviest bulk-freight traffic. For general freight and for light bulk-freight, on the other hand, even this capacity is needlessly high. Even if physical limitations did not govern, the factors of general economy of transportation set a limit to car capacity. On the other hand, engine loadings are of less importance to-day, because aside from local effects they do not amount to more than our maximum train loadings. The heaviest locomotive averages no more per foot of track than the heaviest freight-train. Future slight increases of engine weights on the basis of present-day construction are not likely either to change this state of affairs or to increase the local effects of wheel-loads.

But to give the opposing argument its due, we must recognize that fifty years, or even twenty-five, is a long period of time, and that much may happen before it is over. We may feel able to forecast the detail development of railway practice for five, perhaps for ten years, but can we say as much for 25? Can we confidently assert that the strength of rail, of draft-gear, of car-wheels, etc., and all the other limiting factors of to-day, will not undergo more or less extensive modification? Or that particular kinds of traffic may not develop which will demand far heavier transportation units than 50-ton cars? If electric operation becomes at all extensive, will it remain within the limits of present-day transportation practice in all respects?

There is much force in the lesson of the past, that railway bridges never wear out and never rust out, but always are outgrown; and there is equal force in the oft-repeated lesson that bridge replacement is very costly indeed, besides involving a risk to safety of traffic which in effect still further raises the cost of the undertaking. Experience has not shown us what length of life we can expect from a railway bridge. But it has shown, at least, that for mere durability a bridge may last very much longer than twenty or twenty-five years. In fact, there is no reason why a life of 50 years should not be realized. But if that be true, should we not design for such contingencies as fifty years of the future may bring?

It is not our purpose to suggest anything like the changes of the past quarter-century. The designers of the early 80's might profitably (as we now see it) have doubled the live-loads then existing, before proceeding to design their bridges. Of course railway managers of those days would not have permitted such extravagance. To-day they are more liberal, perhaps. Yet a 100% increase over the live-loads of to-day seems wholly out of reason. A more moderate ratio of increase, however, would be a protection against many future contingencies of load increase, besides giving a margin for the special high loads that need to be transported occasionally, as heavy single pieces of steel, very heavy machinery, large blocks of stone, and the like. In addition it would raise the factor of safety, and give increased security generally.

In spite of this, of course, it may be cheaper to build for only twenty years, and let the future take care of its enlarged requirements. But this would need to be proved by a cost study: whether in the end it is cheaper to build bridges for a small margin over to-day's needs or a large margin, and if the latter then how large a margin.

A recent bit of rivalry in handling long freight trains has some interest in this connection. The New York Central has recently published its marvelous performance of pulling a train weighing about 7,700 tons, from end to end of an entire division of 102 miles, and claims the record for the heaviest freight-train ever hauled. Only a month earlier the Pennsylvania came forward with a haul of 7,644 tons; and just a little before this the new southern coal route, the Virginian Ry., had brought out its record of a 6,023-ton train. These figures are all of them phenomenal. They represent "show" performances, of course, for the strength of draft-gear is an effectual bar for the present to the regular employment of such heavy trains. But they suggest the course of future developments, and indicate clearly that there is a disposition to get full returns out of the extensive line-revisions and grade-reductions in which the leading railways have been investing money during recent years.

LETTERS TO THE EDITOR.

Deep Drill-Holes.

Sir: We have noticed with interest Mr. T. D. Loomis' letter of Aug. 16, in reference to deep drill holes. Your information of Aug. 12 should, of course, have stated that the drill-hole record made at the American Mine in Michigan was for core drills. There are numerous churn-drill or oil-well-drill holes in America exceeding 3,265 ft. in depth. We believe an oil well has recently been completed in California to a depth of about one mile.

In South Africa, a number of exceptionally deep diamond-drill holes have been bored, the deepest of these cutting to 6,340 ft. in search of the main reef series of the Rand gold formation. This hole was bored with a Sullivan Class "P" diamond core drill, removing a 1⅝-in. core. Several other holes bored with these machines have reached depths of over one mile.

Yours very truly,
S. B. King, Sullivan Machinery Co.

Chicago, Ill., Aug. 31, 1909.

Sewer Gas Not the Cause of Disease.

Sir: Your reprint of the summary and conclusions of Mr. C. E. A. Winslow, Biologist, sanitary research laboratory, Mass. Institute of Technology, on the connection between sewer gas and disease [Eng. News, Sept. 2, 1909, p. 238.—Ed.], based upon his valuable experiments for the National Association of Master Plumbers, should, in my opinion, be of great public service. Mr. Winslow's carefully selected methods of investigation can hardly be questioned and they have certainly given us the best analysis of the bacterial content of sewer air yet made. It is a pity that its conclusions will not be read by every one who has visions of death lurking in our domestic sewage after it has left the receptacles into which it has been directly or indirectly deposited. Particularly, it should be widely published that "there would be less danger of contracting diseases from continuously breathing the air of a (sewer) vent pipe or of a soil pipe, excepting (near a point) where liquid is actually splashing, than from drinking New York water," which is pronounced by Mr. Winslow as being "a surface water of good quality."

Such demonstrations should relieve the fear of many women who imagine great injuries to themselves and their children from air which might escape from the sewer pipes, and the fears of many men who, to obviate such imaginary dangers, advocate conditions causing either real dangers or unnecessary expenditures of money.

Relating to this subject, attention might also be called to a paper by Dr. Charles V. Chapin, Superintendent of Health, Providence, R. I., on "Air Infection of Minor Importance," ("Journal" of the American Medical Association, December 12, 1908) which gives an able review of this subject. Some of the conclusions are:

Bacteriology teaches that former ideas in regard to the manner in which diseases may be air-borne are entirely erroneous; that most diseases are not likely to be dust-borne and they are spray-borne only for two or three feet, a phenomenon which after all resembles contact infection more than it does aerial infection as ordinarily understood. Tuberculosis is more likely to be air-borne than is any other common disease.

Pathology has not determined, as is sometimes alleged, that even pulmonary consumption is an air-borne disease.

Besides scientific experiment, practical experience demonstrates the same facts. When in 1880 I visited a large sewage pumping station in London (Abbey Mills), an attendant of the sewage screens, no doubt the filthiest point in the metropolis, had been promoted, and in a short time there were several dozen applicants for the position. The attendants remaining looked healthful and said that colds were the only illness they had ever had. The position was attractive because the work was permanent and the pay was good.

In the midst of a 5,000-acre municipal sewage farm south of Berlin was a sanatorium for the poor. The death rate on the farm, including that of the sanatorium, was less than the death rate of Berlin.

Sanitarians on the continent as a rule have not feared contagion from sewer air. Practically all their cities ventilate the public sewers through the soil pipes of private houses, and the results are much better in the way of ventilation than in England, where as a rule each house has a trap disconnecting it from the public sewer. On the continent, minor officers went with me through the sewers and occasionally inspect them in person as a regular duty, but in England, where ventilation is not so good, I had to be content with a laborer as a companion. Although I have myself walked through a great many sewers, sighted through many and crawled through some, I have never had a resulting sickness.

What practical experience has indicated, scientific experiments have demonstrated. It would be a great gain to the sewerage systems of our cities and cause an improvement of their conditions in preventing many local nuisances if, encouraged by the results of Mr. Winslow's experiments, the care of the sewers was not generally left wholly to the mercies of the men in the cleaning gang.

Very truly yours,

Rudolph Hering.

170 Broadway, New York City, Sept. 7, 1909.

Some Experience with Graduate Engineers; The Need of Teaching Accuracy.

Sir: Having seen several statements regarding engineering education lately in Engineering News, I would like to relate my experience with young engineers.

During the past three years I have employed, among others, one graduate of the Rensselaer Polytechnic, one undergraduate who had finished one year of the course there and one who had finished two years, one graduate of the Utah Agricultural College, two undergraduates of the same, one graduate of Purdue University, one graduate of the University of Michigan, one who had spent two years in the Massachusetts Institute of Technology, one undergraduate of the University of Wyoming, ten in all, and all the graduates had had less than one year's experience.

Out of the above there was only one man who could do work correctly. I mean by this that none of the others could calculate a 20-course traverse, take all the time they desired to do the work, and hand in the correct result. The traverse was to be worked with 15′ traverse tables and so was simple. All of them did calculating without checking as they proceeded. None of them understood methods of checking by nines. All, except the one mentioned above, were incapable of turning 20 angles on a transit and reading them correctly in the course of a survey. Four of them could not run a line of plain differential levels, using a self-reading rod, and put down the correct readings. Given a grade height at each end of a line, and shown how to figure intermediate grades at irregular distances, five failed to calculate the heights correctly. Given all the time they desired and asked to multiply five sets of four figures multiplied by three figures—such as 5,285 × 328 — 4,356 × 459 — 5,765 × 985 — 3,214 × 624 — 9,834 × 786—and asked to make these multiplications once only, without checking, four were tried and all of them failed to get the correct results.

Nearly all of them have told me that correctness in result was never impressed upon them. Some of these men even went so far as to say they had been told by their teachers, when working out mathematical problems in college, that the result did not make much difference, so long as they had the correct method of working a problem.

One of the above men has been with me a little over a year and at present he is A No. 1. Any work he does now can be depended upon as far as any reasonable man could expect. Very, very rarely does he make an error in any of his work. This goes to show that accuracy can be taught and learned. To attain this degree of accuracy required very hard work on his part and an immense amount of care.

A year ago this man had no method whatever in calculating. He would figure haphazard over a sheet of paper and often could not retrace his calculations; he was also liable to read a transit wrong by 10° or by 180° and not discover his blunder.

An engineering graduate, it seems to me, has sufficient mathematics in his college course, beginning with arithmetic and ending with the calculus, to be trained to be reasonably accurate and he should be able to make an ordinary simple multiplication or division and get the correct result the first time. If what some of the above men have told me is true, viz., that use of the correct methods is held to be important, but that correct results are not insisted upon by instructors in engineering schools, then I am not surprised at the above-mentioned facts.

Let me say that I would not expect a recent graduate to run a line of levels with a green rodman on a line ascending say 125 ft. in half a mile and run it correct within say 0.02 of a foot. Such a thing requires practice, knowledge of a level, experience in watching the rodman, swinging the rod, etc. I think, however, that it would be reasonable to expect that if he were getting the levels of 26 stakes, a hundred feet apart, and reading them to the nearest tenth, that none of the levels should be a foot out, owing to erroneous reading of the rod, nor should any of them be four-tenths out, owing to some other reason. I have, however, known this last to happen.

As has been said, a man's engineering education is a tool for use in his profession. He must learn how to use it. But when a man has graduated from a school of engineering or is a student within its walls he should have drilled into him the fact, that accuracy is one of the keys to success. My experience given above seems to show that it is not so taught. "Hinc illae lacrimae."

W. Newbrough, M. Am. Soc. C. E.

Evanston, Wyoming, Sept. 5, 1909.

The "Practical" in Conflict with the "School" Idea, and an Illustration from a 24-mile Mountain Railway.

Sir: You devote a little over nine columns of valuable space to Mr. Llano's article on the practical man in engineering. Mr. L. says:

> The beginner should be careful as to whom he takes counsel with. He should regard with distrust the man who, claiming to be a good engineer, boasts of his ignorance of mathematics, for that man is likely to know engineering no more than a quack doctor knows medicine.

I am that "Likely Individual." I am not boasting of my ignorance of mathematics, but have grave doubts whether I would have been able to have done any better if I had got beyond Ray's first part Algebra and his Higher Arithmetic—this latter I have mostly forgotten.

Mr. L. gives instances of asinine questions asked him, making the mistake of quoting the authors as "engineers"; but it is easy enough to retaliate with asinine questions by graduates in engineering. Ibid: In running in a curve I missed the tangent point 7 or 8 ft. and said (knowing my angle was right and the tangents rightly measured): "We will fudge it in." Getting in camp and thoroughly searching Henck he gravely asked me: "Mr. Abbott, I can't find anything in here about 'fudging curves.'"

A professor in engineering of a State University took his vacation on railroad work, was given charge of a trestle, put in a tack head as the center of the piles, had all his levels run out to thousandths, and cut off the piles 2 ft. too short—they didn't find it out until they got to the caps—because with all his learning he didn't know how to check his levels.

SPRINKLING PIPE ON A TRESTLE OF THE KLAMATH LAKE R. R., OREGON, TO PROTECT AGAINST FIRE DURING THE DRY SEASON.

Mr. L. also objects to Trautwine's criticism of Rankine, Mosely and Weisbach. The latter's Mechanics is used as a text-book in the State University of Wisconsin; a page and one-half about is devoted in telling how to oil the step of a turbine wheel; such a thing as oiling a step hasn't been done for 40 years if it ever was.

Mr. L. also says Trautwine fell into very serious errors in the treatment of some mechanical principles. As Trautwine is practically the standard and no matter what else the engineer has he always has a Trautwine, and his statements are accepted and sworn to by the whole engineering profession, Mr. L. can confer the greatest favor ever by pointing out these errors, so that we, the uneducated, may avoid the rocks under our bows.

Mr. L. also speaks of conceited "Ignorance"; I fail to see where that is any worse than Conceited Learning.

I agree with Mr. L. as regards logarithms. Why are they not taught in the public schools? They are so easy to learn, and any bright boy or girl with little instruction can readily master them. Why is it necessary to inject three or four years of mathematical rubbish before they are brought on? Why do not the ones who are competent to write mathematical text-books do it, instead of such professors as Wentworth, who talks about *Straight angles*, etc., etc.

Results are the only things that count. Admit it, that a piece of work accomplishes its purpose and further theorize that much better and much cheaper construction would have done the same. One is an absolute demonstration and the other isn't. Vide Corporal Trim, "That one shove of the Bayonet is worth a thousand homilies on the Art of War." A dam that won't "blow," a structure that carries the load, a sewerage or water system that answers the purpose, and a criticism of why the best was not done is untenable. Such a criticism is exactly on a par of that used by a party in the North after the War of the Rebellion, "Oh, yes, you saved the Union, but it took you too long and cost too much money."

There is a happy medium which should combine and perfectly blend theory and practice. The engineer of learning and master of higher mathematics should be able to have the shrewd horse sense and rapid intuitive, accurate knowledge and judgment of the practical man, which in only the rarest instances he does have and vice versa.

I make the assertion that the engineering works done by college men have failed as often and open to as much criticism as that done by what is called the practical man.

Incidentally the great engineering works that have been the pioneers haven't been accomplished by college graduates.

Mr. Llano has given us a long article and does not state anything on "information and belief" but all as petrified fact. I am always met, when there is a doubt, with a "How do you know," and in order to give due credence to his article I only ask Mr. L. what single or several important works has *he* had charge of that he can cite us to as entitling him to give advice. The small audience of a school room is not the larger ways of men.

E. T. Abbott, M. Am. Soc. C. E.

Klamath Lake R. R. Co., Pokegama, Ore., Aug. 27, 1909.

[However much we may be in sympathy with Mr. Abbott's argument, we do not approve of the rather intolerant or at least impatient spirit that speaks out his letter. We are inclined to differ with Mr. Abbott, also, when he says that

> the engineer of learning and master of higher mathematics should be able to have the shrewd horse sense and rapid intuitive, accurate knowledge and judgment of the practical man . . . and vice versa.

While we admit that there are several grains of truth in this assertion, we do not concede it in its full sweep.

Further, there may be a legitimate doubt on the question whether good practical judgment dictates "fudging" curves (this subject is outside the college curriculum, on the principle that the college teaches only the fundamentals, fudging being regarded as a detail of practice to be acquired later, we suppose; yet many students get a good grip on it even in their school period). In Mr. Abbott's instance, as the angles were right and the tangents were right, very likely the transit was at fault. He himself, presumably, will admit that in some classes of curve location fudging for a total of seven or eight feet is not permissible. But then one may ask, in all fairness, whether the kind of work that permits of such fudging is not more practically treated by throwing in a standard curve (without stopping to calculate tangents, etc.) and then fudging the points to suit the ground and swing the curve flush into the final tangent. By neglecting this broader question, Mr. Abbott's illustration of curve location recoils on himself, as a half-

hearted compromise between scholastic method and practical quick achievement.

The force of the claim for need of practical sense in all engineering work is perhaps not fully apparent from Mr. Abbott's letter above. We believe it is illustrated more fully in a description which he recently sent us, of a sprinkled trestle on the Klamath Lake Railroad.

The adjoined halftone shows this trestle, with a water-pipe laid along the middle of the deck, spraying water over the structure from a number of holes. He states the circumstances and details as follows:

> The trestle is 760 ft. long, 86 ft. high in center, and about half of it an 18° curve. We burn wood in locomotives, and from May to November there is hardly a drop of rain, everything being as dry as tinder and the risk from fire serious. I have little confidence in watchmen, and the burning of this structure would put us out of business.
>
> Fortunately there was a small mountain stream within 1,000 ft. where I could get a head of about 75 ft. I piped to the trestle with a 2-in. pipe laying in center of bridge between the rails a 1-in. and ¾-in. pipe. Every 5 ft. with a file I just cut through, making a spray as shown, and being, I believe, an absolute protection.
>
> I wrought better than I knew, because the water falling to the ground irrigated under the trestles so there is caused a very heavy growth of vegetation.

This example illustrates the truth of the observation that not all good methods are found in books. But it proves too much, for originality and resource are personal qualities, and, while they cannot be taught in schools, neither are they acquired by virtue of the "practical" school through which the "uneducated" man must pass.—Ed.]

Notes and Queries.

B. J., Kansas City, Mo., desires records of cases where sewers have been built on steep grades so that high velocity occurred in the flow, with statements as to how satisfactorily the sewer operated, how the invert withstood erosion, etc. We do not now recall any particular published data on this point, and the subject is one of enough general interest to justify some engineer in making a study of the subject and preparing a paper for publication.

Disinfection as an Adjunct to Water Purification.*

By H. W. CLARK,† and STEPHEN DE M. GAGE.‡

Extensive studies of disinfectants in connection with water and sewage purification have been in progress at the Lawrence Experiment Station for a number of years and much has been learned concerning both the effectiveness and the cost of such treatment. Of the many disinfectants tested, copper salts, permanganate of potash and bleach are the only ones which have shown any promise of usefulness, and it is with the last two that this paper has to deal.

The action of bleach and the permanganates in water are quite similar, both are oxidizing agents and it is to this oxidation that their disinfecting action is due. Unlike copper, neither of them retains its identity for any length of time in the water, and the slight increase in the permanent hardness caused by the use of bleach, or the small traces of manganese which may remain in solution after permanganate treatment, cannot have any possible physiological action upon the consumer.

Disinfection with Permanganate of Potash

The fact that the numbers of bacteria in water are considerably reduced by the use of permanganate has been known for many years, and the permanganates of potash, of soda and of lime have been employed to a limited extent in a number of places. During the Boer war, potassium permanganate was used to disinfect drinking water for the British troops in the field. At Bloemfontein, South Africa, permanganates have been added to the water as it enters the storage reservoir for some years.

Many experiments have been made at the Lawrence Experiment Station to determine the disinfecting power of potassium permanganate when added to water in various proportions. A complete sterilization of the water was not effected in any of these experiments even when the action of large amounts of permanganate was continued for many days. Over 98% of the bacteria were eliminated by treatment with 5 parts per million for four to six hours. Larger amounts of permanganate or a continuation of the action for longer than six hours did not result in any further appreciable decrease in the numbers of bacteria, and B. coli were found in a majority of the samples after treatment.

The cost of treatment with 5 parts $KMnO_4$ per million would be from $3 to $4 per 1,000,000 gals. From these results it appears that while permanganate treatment may have some value as an emergency measure for preparing drinking water in the field, on account of its small efficiency and high cost its use for disinfection of municipal water supplies is limited.

Disinfection with Bleaching Powder.

A large number of experiments were made to determine the effect of various amounts of bleaching powder and the effect of varying lengths of storage after treatment upon the bacterial content of various waters and sewages. The results of these experiments showed that the disinfecting power of the bleach is exhausted in one to two hours where small amounts are used, but that when large amounts are used four to six hours or even longer storage is necessary before the action is complete.

In general, the treatment of Merrimack River water with one part per million chlorine resulted in an effluent corresponding in bacterial quality with the effluents from the best slow sand filters. Much larger amounts are required, however, to produce complete sterilization. In many of the experiments the maximum amount of bleach used, equivalent to 40 parts available chlorine per million, was insufficient to produce complete sterilization, although a reduction of over 99.5% of the bacteria was produced by a chlorine equivalent of 0.5 to one part per million.

Bleach in Combination with Sulphate of Alumina in Mechanical Filtration.

During studies of the purification of the Merrimack River water by a mechanical filter in 1908, using sulphate of alumina and soda as coagulants, it was demonstrated that while a fairly satisfactory effluent from a chemical and physical viewpoint could be obtained by the use of sulphate of alumina in the proportion of .5 to 1 grain per gal., and effluent containing low numbers of bacteria could be obtained only by the use of about 2 grains of coagulant per gal. Using sulphate of alumina in these proportions a fairly satisfactory effluent was obtained, although one not as good bacterially at all times as those obtained from sand filters operating at lower rates without coagulants. Beginning Dec. 1, 1908, attempts were made to reduce the cost of treatment by using only such amounts of sulphate of alumina as were necessary to produce a water of satisfactory appearance, and to reduce the bacteria to a safe limit by adding bleaching powder at the same time as the coagulant. During the first four months of this treatment the proportions of chemicals were changed many times for experimental purposes, and a variety of results were obtained, but for the purpose of comparing the results obtained when disinfection was and was not used, only the results obtained in the period from April to August of each year will be considered. During 1908, about 1.8 grains of sulphate of alumina and 1.5 grains of soda were used per gallon. During 1909, the sulphate of alumina was cut to 0.9 grain per gallon and the soda to 0.7 grain per gallon and bleach equivalent to about 1 part per million available chlorine was used.

During the period when coagulation alone was used the color of the raw water was reduced from 0.43 to 0.09, a reduction of 79%. During the period of combined coagulation and disinfection the color of the raw water was reduced from 0.39 to 0.15, a reduction of about 61%. The removal of organic matter was about 55% during the period of simple coagulation, and about 35% during the period of combined disinfection and coagulation. During both periods the filtered water was free from turbidity and sediment. While the amount of organic matter in the filtered water, albuminoid ammonia and oxygen consumed, was greater during the period when sulphate of alumina was being used in combination with bleach, than during the earlier period when larger amounts of coagulant were being used alone, it was no greater than in many municipal water supplies considered to be of good quality. The amount of color in the filtered water during the latter period of operation averaged 0.15, and was probably as high as could be allowed in practice without being noticed by the consumers. Better removals of color and organic matter could have been obtained by increasing the coagulant during the latter period, but this would have increased the cost and have defeated the object of the experiment.

From a bacteriological viewpoint, the results of combined coagulation and disinfection were far better than those obtained by coagulation alone, the average removal of bacteria by the combined process being 99.7% as compared with a removal of 98.1% during the corresponding period when no disinfectant was used. The effect of disinfection was most noticeable in the character of the water as it flowed to the filter from the coagulation basin. Here a removal of 99.5% of the bacteria was effected during the disinfection period as compared with a removal of 66.7% during the period when coagulants alone were used. During the period of simple coagulation the average number of bacteria in the water applied to the filter after coagulation was 1,900 per c. c. and in the filter effluent was 110 per c. c., while during the period when bleach was used the numbers of bacteria averaged 20 per c. c. in the basin effluent and 13 per c. c. in the filtered water. Not only was the combined coagulation and disinfection more satisfactory as judged by the removal of bacteria but it was eminently more satisfactory as judged by the consistently low numbers of bacteria both in the effluent from the coagulation and sedimentation basin and in the effluent from the filter. To state the bacterial results differently, about 50% of the samples of filter effluent contained more than 100 bacteria per c. c. and B. coli were present in 1 c. c. in 12% of the samples during the period when coagulation alone was used, while only about 1% of the filtered water samples contained more than 100 bacteria per c. c. and B. coli were not found in 1 c. c. of the effluent during the time the disinfectant was employed. Furthermore, during the disinfection period none of the samples of the settling basin effluent contained more than 1,000 bacteria per c. c. and only about 2% contained more than 100 bacteria per c. c., filtration in this case acting merely as a factor of safety so far as bacterial quality was concerned, the elimination of bacteria being practically effected in the coagulation and sedimentation basin. On the other hand, when coagulation alone was practiced, over 54% of the samples of the basin effluent contained 1,000 or more bacteria per cubic centimeter and the burden of producing a bacterially safe water fell upon the filtering medium.

With sulphate of alumina and soda at 1 ct. per lb., and bleach averaging 37% available chlorine at 1¼ cts. per lb., the cost of treatment averaged about $4.80 per million gallons for plain coagulation, and about $2.70 per million gallons for combined disinfection and coagulation. In other words, a saving of about half the cost of chemicals was effected by the use of the combined process, with the production of an effluent of much better quality bacterially and only slightly inferior chemically.

Disinfection of Merrimack River Water after Filtration Through a Roughing or Pre-filter.

On Feb. 1, 1909, studies were commenced of the continuous disinfection of Merrimack River water after it had been passed through a roughing or pre-filter at a rate of 50,000,000 gals. per acre daily. The effluent from this filter flowed into a tank with a capacity of 30 minutes flow from the filter, and it was in this tank that the disinfection experiments were made. The amount of bleach to be used was judged entirely from the bacterial analyses, the attempt being made to obtain an effluent of the same quality as that obtained from the best water filters, by the use of the least amounts of disinfectant.

During February, with bleach equivalent to 0.16 parts per million available chlorine the average bacterial removal was about 91%, and while many of the samples were of satisfactory quality, over 60% of the samples contained more than 100 bacteria per c. c. During March, April, May and June, the bleach used averaged about 0.35 parts per million available chlorine. In this period the number of bacteria before disinfection varied from less than 200 to about 2,300 per c. c., and the numbers after disinfection varied between 22 and 220 per c. c. During March the bacterial removal averaged 86%, 26% of the samples contained more than 100 bacteria per c. c., and 4% of the samples contained more than 1,000 bacteria per c. c. In April the average removal of bacteria was 76%, 19% of the samples containing more than 100 bacteria per c. c., and 10% more than 1,000 bacteria per c. c. Throughout May the effluent was of satisfactory quality, none of the samples containing as many as 100 bacteria per c. c., but owing to the low numbers of bacteria in the water before disinfection the average removal was only 86%. During June the average removal of bacteria was 91%, but 14% of the samples contained more than 100 bacteria per c. c. During July the proportion of bleach was increased to 0.46 part per million available chlorine. The result was an average removal of 99% of the bacteria with none of the samples showing more than 100 bacteria per c. c. The cost of disinfection during July when it was most efficient was about 20 cts. per million gallons.

As the experiment was continued, it was evident that while very small amounts of bleach were effective most of the time, much larger amounts must be used at all times if a constantly effective disinfection is to be maintained, since there is no means of determining when the smaller amounts will fail to be effective except by waiting for the results of the bacterial analyses.

Conclusions.

In conclusion it may be stated that a complete sterilization of a highly polluted water of the character of the Merrimack River cannot be obtained by the use of either permanganate of potash or bleaching powder, except by the use of extremely large amounts. By the use of permanganate in the proportion of 5 parts per million or of bleach in the proportion of 1 part per million, a reduction in total bacteria amounting to about 33% may be obtained.

When bleach is used in combination with sulphate of alumina in mechanical filtration, a satisfactory bacterial

*Abstract of a paper presented before the New York Convention of the New England Water-Works Association, Sept. 9, 1909. The complete paper will be published in the Journal of the Association.

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removal may be obtained at much less expense for chemicals than when sulphate of alumina is used alone. In such a process, the disinfection occurs in the coagulation basin before the water reaches the filter, and subsequent filtration introduces a factor of safety which greatly adds to the effective purification of the water, and greatly reduces the chances of the occasional failure of the process. In the experiments quoted, an effluent of better quality bacterially was obtained by the use of about 0.9 grain sulphate of alumina and about 0.7 grain of soda per gallon, in combination with bleaching powder equivalent to 1 part per million available chlorine, than when double the amounts of sulphate of alumina and soda were used without the disinfectant.

The experiments upon the continuous disinfection of Merrimack River water after its passage through a high rate roughing or prefilter indicate that in order to obtain an effluent containing low numbers of bacteria at all times, the use of bleach equivalent to 0.5 to 1.0 part per million available chlorine will be necessary.

A FREIGHT TRAIN STRUCK AN AUTOMOBILE on a Philadelphia & Reading Ry. grade crossing in Philadelphia, Pa., Sept. 12. The eight persons in the automobile were severely injured. The accident occurred at an early hour in the morning and is ascribed by the driver of the automobile to the absence of lights on the crossing gates.

A HEAD-ON COLLISION on the Chicago, Burlington & Quincy R. R., at Burnham station, four miles southwest of Lincoln, Neb., Sept. 12, killed two men and injured nine others. Passenger train No. 80, southbound, collided with an extra stock train. The passenger locomotive, which was much lighter than the freight, was driven back into the combination express and baggage car, which in turn partly telescoped the smoker. The accident is attributed to a misunderstanding of orders.

A construction train on the Huntingdon & Broadtop Mountain R. R. collided head-on with a freight train drawn by two engines in Red Rock cut near Riddlesburg, Pa., Sept. 1. Three men were killed and two others injured, and two locomotives and 14 cars were wrecked. The accident is ascribed to an operator's failure to deliver orders to one of the train crews.

A SWITCHING ACCIDENT in the yards of the Chicago & Alton R. R. at Auburn, Ill., Sept. 4, resulted in the death of five track laborers. Six men had taken refuge from the rain beneath a freight car. A string of freight cars was backed into the car they were beneath, moving it several feet along the track, and five of the men were crushed beneath the trucks.

TWO ELECTRIC RAILWAY ACCIDENTS of a very similar character were reported last week. A local train on the Elgin & Belvidere Ry. collided head-on with a limited train at a curve one-half mile southeast of Huntley, Ill., Sept. 8. Twenty-three passengers and five trainmen were injured.

A local car on the Wilkes-Barre & Hazleton Ry., a third-rail line, collided with a special near Hazleton, Pa., Sept. 6. Both cars were demolished and 50 persons were injured. Both this accident and the one at Huntley, Ill., is ascribed to the failure of the motorman of the local to wait on a siding for the other car to pass.

A SEWER TRENCH CAVE-IN on 148th St., Chicago, Ill., caused the death of two workmen and the injury of 15 others. At the time of the accident, 25 men were at work in the trench, which was about 10 ft. deep. Reports state that, at the point where the cave-in occurred, the trench was dug in quicksand.

A FREIGHT TRAIN STRUCK A STREET CAR at a grade crossing on the Missouri Pacific Ry. at St. Louis, Mo., Sept. 11. Twenty passengers were injured, three very seriously. Gravois Ave., at the point where it is crossed by the Missouri Pacific tracks, has a steep grade and the crossing is locally known as the "slide of death." The street car was coming up grade at high speed, while the railway train was running at a speed of only 4 mi. per hr. The crossing gates were lowered but, it is claimed, the motorman was unable to stop his car and, after applying the air brakes, decided that they would not check the car in time to prevent the collision and put on full power in an effort to cross in front of the locomotive. The street car broke through the nearer crossing gate and succeeded in nearly crossing the tracks, but was struck on the rear platform and swung around almost at right angle to its course. The car was of steel construction and was only slightly damaged.

A POWDER-MILL EXPLOSION Sept. 3 at Wayne, N. J., wrecked one of the buildings of the Du Pont powder works. One man was killed and three others were seriously injured. The explosion occurred in the wet mixing mill and is ascribed to sparks caused by grit on the shoes of the man who was killed, who had entered the building a few seconds before the explosion. Felt-soled shoes are worn by the powder mill employees to guard against this source of danger.

THE "MAURETANIA," on the westward trip ending Sept. 9, broke the transatlantic record established about a week ago by her sister ship "Lusitania." The new record for time between Daunt's Rock and the Sandy Hook lightship is now 4 days 11 hrs. 35 min., or only seven minutes less than the record of the "Lusitania." This last feat was done in spite of fog on one day and poor coal.

A LARGE NATURAL BRIDGE is reported from Utah. Its size is given as: span 274 ft., height over 300 ft. Its location is 6 miles east of the Colorado River and 4 miles north of the Arizona line. The Utah Archaeological Society announces the discovery.

A CHECK TO HYDRAULIC MINING in California has been given by the California Debris Commission in its recent decision that all dams hereafter constructed to hold back tailings or mining debris must be built of masonry or concrete and be permanent rather than temporary in character. Where the mining operations have not been carried out on a large scale, log and brush dams previously have been approved and have appeared to answer the purpose. In these instances, the expense of building the more substantial dams would render mining unprofitable. It is claimed by the small operators that they will be forced out and that hydraulic mining can be carried on only in those regions reached by the larger concerns whose operations will stand the added expense.

THE FASTEST BOAT IN THE U. S. NAVY is the torpedo boat destroyer "Flusser" which underwent the first of her official acceptance trials Sept. 1 on the one mile course at Rockland, Me. The highest speed maintained over the course was 33.7 knots and the average for her five top-speed runs was 32.7 knots. The "Flusser" has a displacement of 700 tons and developed in the trial a shaft horse-power of 14,400. She is driven by Parsons turbines.

WORK ON THE GATUN DAM is to be expedited by putting on an additional 20-in. suction dredge, which has been purchased and is to be delivered before the close of the year. This will make four dredges at work filling the dam, and another may be added in 1910.

PANAMA CANAL EXCAVATION IN AUGUST totaled 2,755,178 cu. yds. place measurement, a decrease of about 100,000 cu. yds. against July. There were 26 working days (as in July); the rainfall was 9.28 ins. (10.66 ins. in July). The fill placed in the dams during August was 454,677 cu. yds., and the concreting amounted to 7,643 cu. yds., both figures being slight reductions as compared with July.

A PERMANENT SAMPLE EXHIBITION of American products will be opened in Berlin, Germany, in the spring of 1910. This exhibition will be in charge of the American Exhibition Co., of 77 Broad St., New York City. It is designed as an exhibit of distinctively American products and it will be advertised throughout the continent. It is claimed that the scheme is endorsed by the American Ambassador, by the Department of Commerce and Labor and by local consuls in Germany.

THE CAR SURPLUS IS DECREASING RAPIDLY and on Sept. 1 amounted to only 110,576 cars, of which one-half were box cars. The decrease during the two weeks preceding was 48,848 cars. The present surplus is about 100,000 lower than at the same time in 1908. The lowest point reached last year was 111,000 on Oct. 28, 1908. If railway activity continues to grow until the same date this year, a perceptible shortage may be looked for. Local shortages, which exist even at a time of maximum surplus, have increased slightly during the last month, and now are near 4,000. On Oct. 28, 1908, local shortages totaled 11,000. The American Railway Association report, from which the new figures are reported, makes the estimate that the situation of this year is fully two weeks earlier than last year's.

REBUILDING THE PARKER BUILDING is to be undertaken at once. The Parker Building was a 12-story "fireproof" loft building at Fourth Ave. and 19th St., New York City, which was gutted by fire Jan. 10, 1908 (see Eng. News, Jan. 16, 1908, p. 73; May 21, 1908, p. 567). The new building will be for the same kind of occupancy as the old; it will be known as the Pocono Building. It will be 40 ft. narrower north and south, by omitting two bays of the old structure along the south side. The remainder will employ largely the material of the old frame (cast-iron columns and steel beams), on which the underwriters estimated only 26.3% damage. The floor-arches, which were one of the weak features of the Parker, will be thicker in the Pocono, though of the same material, hollow terra cotta. They will be end-construction, with side skewbacks and keys. The 6-ft. spans are to be built of blocks 12 ins. thick, the 4½-ft. spans of blocks 10 ins. thick (all arches were 8-in. in the Parker). This will also reduce the weight of fill over the arches, which in the old building was excessive. Concrete floors will top off the fill. The soffit of the arches is 1½ ins. below the beam flanges, and thickened lips projecting latterally from the skewback blocks will furnish a 2-in. terra cotta fireproof covering for the flanges. The protection of the columns, which also was insufficient in the Parker Building, is to be 3-in. terra cotta. All stair and elevator shafts will be enclosed by terra-cotta partitions, with wire-glass in the doors. R. H. Robertson & Son are the architects for the Pocono Building.

THE QUEBEC BRIDGE COMMISSION is working out plans for both a cantilever bridge and a suspension bridge to occupy the place of the cantilever structure which collapsed during erection, Aug. 29, 1907. The commission, with the help of Mr. Henry Holgate and Mr. Alfred Noble as consulting experts, decided to use one of the present piers, strengthening it, however, to bear an increased load, and to build a new pier on the other side of the river about 100 ft. riverward of the present location. This will make the central span 1,715 ft. In determining the characteristics of the superstructure, it was again necessary to call in consulting experts, as the commission could not agree. Mr. Paul Wolfel and Mr. Phelps Johnson were called in. In the case of the cantilever design, the old requirement of 1,200 ft. width of maximum clearance has been abandoned, and a clearance width of 600 ft. adopted. The clearance remains 150 ft., as before. The outlines of the cantilevers, it is reported, will be straight instead of curved. It is understood that the commission will work out complete designs, as a basis for bids. The commission itself gives no information as to its doings, but a public statement of Mr. George Graham, the Minister of Railways and Canals, and other local information published by the Montreal "Gazette" of Sept. 8 giving the above data are admitted to be correct.

Personals.

Mr. I. L. Simmons has been appointed Bridge Engineer of the Rock Island Lines, with headquarters at Chicago, Ill.

Mr. W. B. Storey, Jr., Chief Engineer of the Atchison, Topeka & Santa Fe Ry. system, has been made a Vice-President.

Mr. Jackson Smith, formerly in charge of labor recruiting work on the Panama Canal, has become Vice-President of the Oregon Trunk Line.

Mr. Gilmour Brown, of St. John, New Brunswick, has been appointed Assistant Chief Engineer of the department of public works at Ottawa, Ont.

Mr. James H. Norris, M. Am. Soc. M. E., has resigned his position as Business Manager of the John F. Allen Riveting Machine Co., New York City.

Mr. Robt. S. Lovett, Vice-President and General Counsel of the Union Pacific R. R., has become chairman of the Executive Committee, succeeding Edward H. Harriman, deceased.

Mr. Chas. O. Kruger, Vice-President and General Manager of the Philadelphia Rapid Transit Co., has been chosen to succeed Mr. John B. Parsons, resigned, as President.

Mr. E. L. Hancock, formerly Assistant Professor of applied mechanics at Purdue University, has been appointed Professor of applied mechanics at the Worcester Polytechnic Institute.

Mr. J. Roy Dillon, Vice-President and General Manager of the Gulf & Interstate Ry. of Texas, has resigned to engage in other business in New Orleans, La. He will be succeeded by Mr. John Paul Jones, of Galveston, Tex.

Mr. Jerome Cochran, Jun. Am. Soc. C. E., Professor of civil engineering in the John B. Stetson University, De Land, Fla., has opened an office as a consulting and contracting engineer in the First National Bank Bldg., Houston, Tex.

Mr. Robert Hawxhurst, Jr., M. Am. Soc. C. E., has resigned the management of the Poderosa Mining Co., Ltd., Antofagasta, Chile. He will spend some time in examining adjacent properties and will then return to London, England.

Mr. George A. Kyle, Assoc. M. Am. Soc. C. E., has resigned as Principal Assistant Engineer of the Chicago, Milwaukee & St. Paul Ry. to take charge of surveying and engineering work on the Oregon Trunk Line in the Deschutes River valley.

Mr. R. N. Bishop, M. Am. Inst. M. E., has resigned as Mine Manager of the Balakiala Consolidated Copper Co., Coram, Cal., to devote time to personal electric and mining interests. His offices will be at 1121 First National Bank Bldg., San Francisco, Cal.

Mr. John W. Henrekson, Assoc. Am. Inst. E. E., has resigned his position as Assistant Engineer with the Goodman Mfg. Co., Chicago, Ill., and is now Electrical Engineer for the Hisey-Wolf Machine Co., Cincinnati, Ohio. Mr. Henrekson had been with the Goodman Mfg. Co. for the past seven years.

Mr. L. A. Herdt, M. Am. Inst. E. E., Associate Professor of electrical engineering at McGill University, Montreal, P. Q., and Mr. W. A. Lamb, of the Canadian

General Electric Co., Peterboro, Ont., have been appointed as a board of examiners to examine candidates for the position of electrical inspector in the inland revenue department of Canada.

Mr. W. J. C. Kenyon, whose resignation as Vice-President and General Manager of the Illinois Tunnel Co. (Chicago freight subway) was noted in our issue of Aug. 5, has become First Vice-President of George W. Jackson, Inc., Chicago, Ill., and has assumed the duties of General Manager of the railroad contracting department of that company.

Mr. John F. Stevens, M. Am. Soc. C. E., has become President of the Oregon Trunk Line, a railway to be built by the Hill interests from the Columbia River to central Oregon and to San Francisco, Cal. The Oregon Trunk Line, with its extensions, will be about 200 miles long. Mr. Stevens, formerly Chief Engineer of the Panama Canal, resigned that position in 1907, and, in April of that year, he became Vice-President of the New York, New Haven & Hartford R. R. The first twelve months of his vice-presidency were spent in making a valuation of the railroad's property. He resigned this position in June, 1909, and was engaged by the Great Northern Ry. to inspect water-power facilities in Montana and Washington.

Mr. Emmet A. Gould, General Superintendent of the northern district of the Missouri Pacific Ry., with headquarters at Kansas City, Mo., has resigned to become General Superintendent of the Cincinnati, Hamilton & Dayton Ry., with headquarters at Cincinnati, Ohio. He succeeds Mr. J. A. Gordon, resigned. Mr. Gould will be succeeded by Mr. W. J. McKee, formerly General Superintendent of the St. Louis, Iron Mountain & Southern Ry., at Little Rock, Ark. Mr. M. M. Richey, Superintendent of the Arkansas division of the St. Louis, Iron Mountain & Southern, will succeed Mr. McKee as General Superintendent. Mr. J. F. Murphy, Superintendent of the central division, will succeed Mr. Richey, and Mr. C. B. Wildman, Trainmaster at Van Buren, Ark., will become Superintendent of the central division.

Obituary.

John N. A. Griswold, at one time President of the Illinois Central R. R., died Sept. 13 at his home in Newport, R. I., at the age of 88 years.

William W. Doud, a civil engineer of Sharon, Pa., was killed at Mobile, Ala., Sept. 8, by being struck on the head by a large timber which slipped from its fastenings while being hoisted into position in the new plant of the Ohio & Pennsylvania Lumber Co. Mr. Doud was in charge of the construction of the plant.

Frederick Turnbull, President of the Turnbull Construction Co., Philadelphia, Pa., died Sept. 6 at his summer home in Atlantic City, N. J. Mr. Turnbull was born near Glasgow, Scotland, in 1847, and was graduated at the University of Glasgow in 1867, afterward taking up the study of chemistry at the Andersonian University in Glasgow. Upon first coming to the United States, he was employed by the firm of William J. Matheson, Ltd., at Long Island City, N. Y.

Isaac D. Smead, an engineer and contractor of Cincinnati, Ohio, died in Baltimore, Md., Sept. 6, aged 60 years. Mr. Smead was born in Colerain, Franklin Co., Mass., and went to Bloomington, Ill., when a young man. There he established a company for the construction and installation of heating and ventilating systems, and in 1882 he transferred the business to Toledo, Ohio, under the firm name of Isaac D. Smead & Co. In 1897 he removed to Cincinnati, Ohio, and opened an office for the practice of general mechanical engineering.

John Cavanagh, a contractor, of Braintree, Mass., died Aug. 27 at his home in that city at the age of 79 years. Mr. Cavanagh was born at Providence, R. I., and was educated at Thayer Academy and later at the Massachusetts Institute of Technology, where he took a mathematical course of two years. His work as a contractor in the vicinity of Boston, Mass., included the building of the North Harvard bridge across the Charles River and the stone abutments for the Berkeley St. bridge. For three years he was Superintendent of the Quincy, Mass., waterworks.

Ross G. Marvin, an instructor in civil engineering at Cornell University, was drowned April 10, 45 miles northwest of Cape Columbia, the extreme northern point of Grant Land. Mr. Marvin was born at Elmira, N. Y., in 1880, and was educated at Cornell University, where he took the course in mechanical engineering, graduating in the class of 1905. His death was due to his breaking through thin ice while proceeding alone some distance in advance of the supporting party, of Peary's polar expedition, of which he was in charge. His party had joined Peary March 14, taking him supplies, and was on the return journey to the "Roosevelt" (Peary's ship) at Cape Columbia when the accident occurred. Mr. Marvin, before leaving Peary, took observations at latitude 85° 48'. His body was not recovered.

Charles F. McKim, Past-President of the American Institute of Architects, died Sept. 14 at his country home at St. James, Long Island. Mr. McKim was born in 1847 in Chester Co., Pa. He entered the Lawrence Scientific School in 1866, but remained there only one year, for his ambition to become an architect led him to Paris, France, where he took the three-year architectural course at the Ecole des Beaux-Arts. The two years succeeding the completion of this course, he spent in travel studying European architecture. In 1872 he returned to the United States and began his practice in New York City. Five years later he joined partnership with Mr. Wm. R. Mead, and in 1879 Stanford White, who was killed by Mr. Harry K. Thaw in 1906, became a member of the firm. Among the buildings designed by the firm of McKim, Mead & White were the Boston Public Library, Madison Square Garden, New York City; Columbia University buildings, New York City; State Capitol of Rhode Island; Agricultural Building and New York State Building at the World's Columbian exposition. Mr. McKim was a member of the congressional commission for the improvement of the park system at Washington, D. C., and of a number of other art and architectural commissions and societies, and was the founder of the American Academy in Rome. He was President of the American Institute of Architects in 1902-3.

Edward H. Harriman, President of the Southern Pacific Co. and the most prominent and influential railway financier in the United States, died Sept. 9 at his home in Arden, N. Y. Mr. Harriman was born in 1848 at Hempstead, Long Island, in which town his father was rector of St. George's Episcopal Church. His family removed to Jersey City, N. J., when the boy was six years old and his education was obtained in the public schools of that city. At the age of 14 he became a broker's clerk in Wall St., New York City, and in 1870 he bought a seat in the New York Stock Exchange. He became a director of the Illinois Central R. R. in 1883 and was Vice-President of that road from 1887-90. In 1897 he was put in charge of the reconstruction and reorganization of the Union Pacific R. R., which had been purchased in that year from the U. S. Government by a party of capitalists. His work on the Union Pacific included the planning of the Lucin cut-off, which involved a viaduct 23 miles long across Great Salt Lake. In August, 1908, he had come into personal control of 18,000 miles of railway, including the Union Pacific, Southern Pacific, Central Pacific, Oregon Short Line, Illinois Central and Central of Georgia. He is reported to have had also a dominating interest in nearly 26,000 additional miles of railway, including the Chicago, Milwaukee & St. Paul, Baltimore & Ohio and Erie.

At the time of his death he was President of the Oregon R. R. & Navigation Co., Portland & Asiatic Steamship Co., Union Pacific R. R., Oregon Short Line R. R., Southern Pacific Co., Texas & New Orleans R. R., Southern Pacific Coast Ry., Oregon & California R. R., Central Pacific Ry., Louisiana Western R. R., Morgan's Louisiana & Texas R. R. & Steamship Co., Pacific Mail Steamship Co., Railroad Securities Co. and the Southern Pacific Terminal Co. He was a director of the Illinois Central R. R., the Baltimore & Ohio R. R., Erie R. R., Colorado Fuel & Iron Co., Western Union Telegraph Co., Chicago & Alton R. R., Pere Marquette R. R., San Pedro, Los Angeles & Salt Lake R. R., Pacific Coast Co., New York, Susquehanna & Western R. R. and of many other corporations.

William C. J. Eimbeck, of the U. S. Coast and Geodetic Survey, who died at Washington, D. C., March 27, 1909, has been made the subject of a biographical memorial recently presented to the Engineers' Club of St. Louis by Mr. Wm. H. Bryan, M. Am. Soc. M. E. Mr. Eimbeck was born at Brunswick, Germany, in 1840 and was educated at the Polytechnic and Agricultural College, where he showed exceptional proficiency in mathematics. He came to the United States in 1857 and obtained a position as a draftsman with Palm & Roberson, locomotive builders, in St. Louis, Mo. After three years he became assistant and deputy to the county surveyor of St. Louis Co., and retained this position for nine years, during which time he did some work in connection with the Eads Bridge and the St. Louis water-works, then under construction. In 1868 he also became connected with Washington University (St. Louis) as its first professor of engineering and practical astronomy.

His most important work was in the U. S. Coast and Geodetic Survey, with which he was first connected in 1869, when he acted as a volunteer observer of the solar eclipse of Aug. 7. In this connection, he assisted in what is said to be the first determination of the exact longitude of St. Louis. In the following year he was sent to Sicily to observe the total eclipse of the sun. He became permanently connected with the Survey in 1871, when he was appointed a sub-assistant. During the seven years following he was employed upon determinations of latitude, longitude and magnetic elements in a number of the southern and western states.

He took up in 1878 the survey from the Atlantic to the Pacific on the 39th parallel, which occupied 19 years and was really his life work. During his connection with the Survey he invented the duplex base apparatus, designed an invariable reversible pendulum and devised improvements of the Hipp chronograph. He was a member of the Washington Academy of Science, the National Geographic Society and the Geological Society, and was for 30 years a fellow of the American Association for the Advancement of Science. In the paper by Mr. Bryan, from which the above information is taken, Mr. Eimbeck is described as a man of pleasing personality, so modest that few knew of his accomplishments and attainments.

Engineering Societies.

COMING MEETINGS.

ILLUMINATING ENGINEERING SOCIETY.
Sept. 25-27. Annual convention at New York City. Secy., P. S. Millar, 25 W. 39th St., New York City.

AMERICAN MINING CONGRESS.
Sept. 27-Oct. 2. Annual session at Goldfield, Nev. Secy., J. F. Callbreath, Jr., Denver, Colo.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 4-8. Annual convention at Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 12-14. Annual convention at Louisville, Ky. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 29-30. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Nov. 9-11. Annual convention at Little Rock, Ark. Secy., A. P. Folwell, 239 West 39th St., New York City.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 16. Annual meeting at Washington, D. C. Secy., Martin S. Decker, Albany, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At the meeting held in New York City Sept. 15 two papers were presented which were printed in the August "Proceedings": "The Use and Care of the Current Meter, as Practiced by the U. S. Geological Survey," by John C. Hoyt, and "Walnut Lane Bridge, Philadelphia," by Geo. E. Webster and Henry H. Quimby.

CENTRAL RAILWAY CLUB.—At the regular meeting at Buffalo, N. Y., Sept. 10, Col. B. W. Dunn, Chief Inspector of the bureau of explosives of the American Railway Association, gave an illustrated lecture on "The Safe Transportation of Explosives and Other Dangerous Articles." This lecture was the principal feature of the evening session. During the day, the members made a trip down the north channel of Niagara River around Grand Island to Electric Beach and return.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.—At the fifth congress, held in Copenhagen, Denmark, Sept. 7-11, it was decided that the next congress shall be held in America in 1912 with Dr. Charles B. Dudley, M. Am. Soc. C. E., as President. A membership list issued by the association shows members from 27 different countries. Germany leads in membership with 375, Russia is second with 293, and the United States is a close third with 290 members. Members in the association may be public bodies, societies or individuals.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The Western Electric Co. has presented to the library of the American Institute of Electrical Engineers its collection of patent specifications. This gift constitutes the largest accession since the original creation of the library by Dr. S. S. Wheeler with the Latimer-Clark collection.

The patent library which the institute thus acquires contains 461 leather-bound volumes comprising approximately 100,000 specifications. These specifications begin with May 30, 1871, and run to December, 1908, thus covering the entire period of activity which includes the telephone, the electric light, electric railways and the electric motor. From May 30, 1871, up to the last day of 1887 the volumes are complete, containing all the specifications issued by the Patent Department, certified. From July, 1887, up to Dec. 1, 1908, the volumes contain all the electrical specifications which are not certified.

The original set cost over $4,000, and duplicates of these specifications, if now purchased from the Government and bound, would cost between $4,000 and $4,500. This library has been accumulated by the Western Electric Co. in Chicago, from which city it is now being brought to New York to be added to the collection of technical literature housed in the Engineering Societies Building. Mr. Edward Caldwell, chairman of the library committee of the Institute, has already taken the matter in hand as to proper care and installation of the library, so that the members may derive the greatest possible benefit from having such a collection at their disposal, and has also taken measures to complete the set to date. By a fortunate coincidence the Institute had already been presented with a set of specifications antedating the period prior to those included in this gift.